Building Long-term Research Projects and Collaborations

MICHIGAN STATE UNIVERSITY | GK12 Bioenergy Sustainability Project

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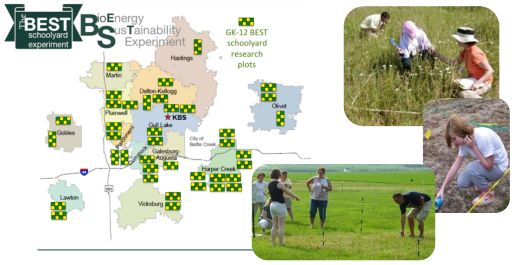
Partner Teacher: Marcia Angle
Leadership: Tom Getty (PI) and Robin Tinghitella (Project Manager)

NSF

KBS GK-12 Project

A central goal:
create a collaborative research network of schoolyard science research sites.



KBS GK-12 Project

Why a schoolyard research network?

- serve as arenas for inquiry science activities
- mimic aspects of KBS and fellows' thesis research
- highlight Fellows' skills as *researchers*
- address MI Science standards
- allow K-12 classes to develop research initiatives
- facilitate cross-district research collaboration

Workshop Goals

Today, we will:

- Outline our experience building the "BEST" research network
- Provide three case studies highlighting how we bring Fellow research skills to bear on the research network
  - Liz: Bringing Fellows' Thesis Research to the Network
  - Nick: Cultivating Scientific Thinking Skills
  - Tomomi and Alycia: Enhancing Students' Research Initiatives
- Consider the benefits and challenges of this type of work

Establishing a research network

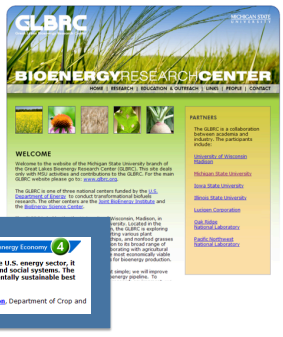
W.K. Kellogg Biological Station's K-12 Partnership – a long-term collaboration

- Established 10+ years ago,
- 80+ participating teachers
- 13 SW Michigan districts
- Trusting relationships with KBS scientists

Establishing a research network

Identifying a Project Theme: "STEM Dimensions of Bioenergy Sustainability"

- KBS expertise
- Regional interest
- Linked to Fellow research



Establishing a research network

Summer Institute 2010:
Fellows introduce Teachers to native prairie and switchgrass treatments –
2 potential biofuel crops studied at KBS

GK-12 Fellow Nikhil and teacher John Edgerton check out a native prairie plot at the GLBRC.

Partner teacher Sandy Erwin observes a switchgrass plot at the GLBRC.

Establishing a research network

Summer Institute 2010:
Collaborated with teachers to develop experimental design, questions/hypotheses to address in our research network

As early as possible, established a structure giving everyone project *ownership* and *important roles* –

Successful partnerships play on strengths that all Fellows and Teachers bring to the table!

Establishing a research network

"Can we grow our fuel and have our flowers and butterflies too?"

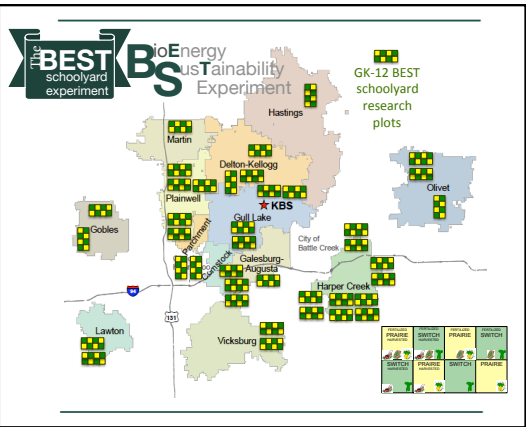
Basic experimental block:
(modeled after the GLBRC)

FERTILIZED PRAIRIE HARVESTED	FERTILIZED SWITCH HARVESTED	FERTILIZED PRAIRIE	FERTILIZED SWITCH
SWITCH HARVESTED	PRAIRIE HARVESTED	SWITCH	PRAIRIE

Manipulate diversity, fertilization, and harvesting

Establishing a research network

Establishing a research network

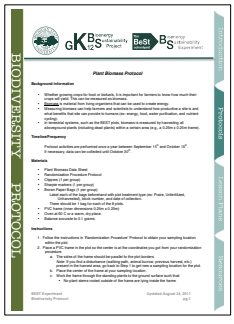


Establishing a research network

2010 School year: designed and tested research protocols and teaching materials with students and teachers

Three theme-teams and sets of protocols:

- Biodiversity and Biomass
- Soils
- Landscape-level



Establishing a research network

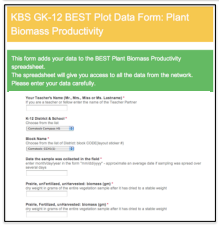
Fall 2011: Data Collection begins on the BEST plots

- Participants in all districts collect the same data using standardized protocols

Establishing a research network

Fall 2011: Data Collection begins on the BEST plots

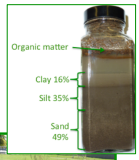
- Data submitted to GK-12 leadership through Google docs web forms.
- Teachers and students have access to data from across the research network



Establishing a research network

Students and teachers can access data from across the research network to ask their own questions:

Here we show preliminary evidence from two districts suggesting that soil properties impact ecosystem productivity and diversity.



Establishing a research network

Districts are working to align curriculum with the BEST plots research network:

Example:

- Elementary – collect prescribed data, and draw simple conclusions based on evidence
- Middle school – pose questions, and conduct experiments designed largely by Fellows and teachers
- High school – develop questions and experiments utilizing techniques learned in previous years of research

Establishing a research network

Research network success relies on the strengths of both Fellows and Teachers:

- Fellows use research strengths to tailor our research question to teacher and student needs
- Teachers use expertise in pedagogy and grade-level content to ensure topics and teaching strategies are relevant and realistic

- By the end of our project (and 5 years of data collection) teachers will have the experience and resources to continue engaging students in authentic research

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- Consider the benefits and challenges of this type of work

GK-12 Fellow Liz Schultheis

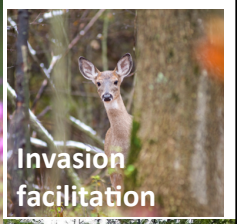
A central goal:
Bringing Fellow Research into the Classroom

- **Opportunity to share my research with a diverse audience**
- **Think about the major ideas behind my research**
- **Think about the broader context of what I study**

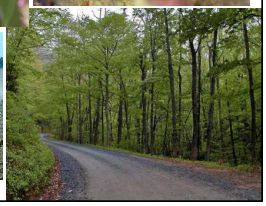
GK-12 Fellow Liz Schultheis

Lythrum salicaria

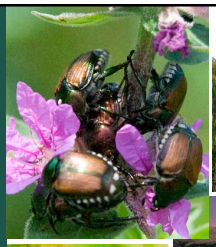
GK-12 Fellow Liz Schultheis



Invasion facilitation



GK-12 Fellow Liz Schultheis



Invasion resistance

GK-12 Fellow Liz Schultheis

Invasive Species Activity
Sharing my research with elementary and middle school students

Integrating Fellow Research

Invasive

Purple loosestrife

Native

Pickerel-weed

Integrating Fellow Research

PURPLE LOOSESTRIFE

Move forward:

Growth:
Seeds:
Disperse:

Move backward:

Herbivory:
Disease:
Fire:
Drought:
Human disturbance:

PICKERELWEED

Move forward:

Growth:
Seeds:
Disperse:

Move backward:

Herbivory:
Disease:
Fire:
Drought:
Human disturbance:

Integrating Fellow Research

PURPLE LOOSESTRIFE

Move forward:

Growth:
Seeds:
Disperse:

Move backward:

Herbivory:
Disease:
Fire:
Drought:
Human disturbance:

- All species can grow, produce seeds, and disperse
- Abilities differ between species

Integrating Fellow Research

PURPLE LOOSESTRIFE

Move forward:

Growth:
Seeds:
Disperse:

Move backward:

Herbivory:
Disease:
Fire:
Drought:
Human disturbance:

- Some actions harm native species more than invasive species
- These actions facilitate invasion

Integrating Fellow Research

PURPLE LOOSESTRIFE

Move forward:

Growth:
Seeds:
Disperse:

Move backward:

Herbivory:
Disease:
Fire:
Drought:
Human disturbance:

- Some actions harm invasive species more than native species
- These actions resist invasion

Integrating Fellow Research

MICHIGAN STATE UNIVERSITY | W.K. Kellogg Biological Station

K-12 Partnership Lesson Plan

ACTIVITIES OF THE SESSION

The lesson has two parts: the introduction and activity

1. Introduction
   a. Ask the students about their prior knowledge on invasive species. Can they name any invasive species? Do they know the issues caused by those species or what people are doing to control them?
   b. Give examples of dramatic invasions in Michigan (presentation contains slides on zebra mussels, emerald ash borer, and Eurasian water milfoil)
   c. What characteristics did all this invaders share? Ask students to pull together what they can remember from their examples and the ones in the presentation. See if they can come up with their own list before showing the slide with characteristics.
   d. Tell students that they will now be participating in activity to learn about the characteristics of invaders that make them successful.
2. Activity
   a. Introduce the rules of the activity. Go over species cards, stages, and events. Describe how students will move backwards and forwards heel-to-toe and that the students who cross the finish line will be "in the community" and will have to describe to the class how they got there.
   b. Gather students in a large, open room
   c. Students line up, shoulder to shoulder on the start line
   d. Give each student a species card (you will not use whole set, ratio of invaders to natives should be about 1:2)
   e. Explain that students will move forward for stages (growth, seeds, reproduction) when the appropriate stage sign is held up. They will

Integrating Fellow Research

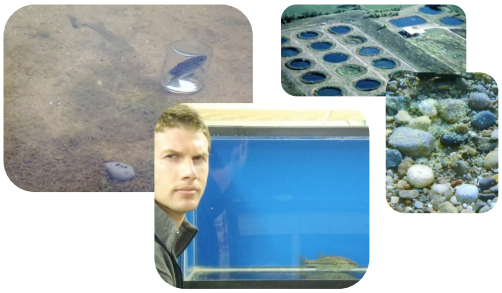
Connecting my research to the Research Network:
Bringing Fellow Research into the Classroom

- Think about broader context of my research
- Can do basic ecology in the classroom –
  the Network and classroom inquiry activities



GK-12 Fellow Nick Ballew

Cultivating critical thinking skills:
implementing a lesson structure
that focuses on critical thinking.



GK-12 Fellow Nick Ballew

Cultivating critical thinking skills:
implementing a lesson structure
that focuses on critical thinking.

THE THREE DIMENSIONS OF THE FRAMEWORK

1 Scientific and Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

2 Crosscutting Concepts
1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

3 Disciplinary Core Ideas

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas

Committee on Conceptual Framework for the New K-12 Science Education Standards; National Research Council

GK-12 Fellow Nick Ballew

Cultivating critical thinking skills:
a condensed example to demonstrate
the general lesson structure.

Question: How does N fertilization affect switchgrass production?

Claims:

1. Nitrogen fertilization does not affect productivity.
2. Nitrogen fertilization usually helps, but never hurts switchgrass productivity.
3. Nitrogen fertilization can help, but too much can harm switchgrass productivity.

GK-12 Fellow Nick Ballew

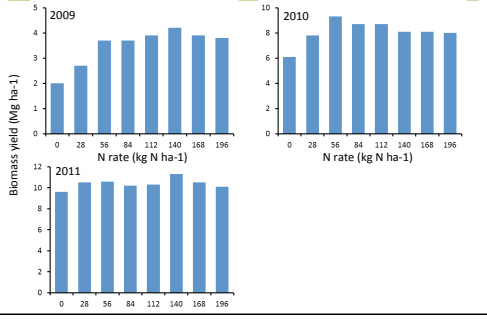
Core Critical Thinking Skills

SKILL	Experts' Consensus Description	Subskill
Interpretation	"To comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or criteria"	Categorize Decode significance Clarify meaning
Analysis	"To identify the intended and actual inferential relationships among statements, questions, concepts, descriptions, or other forms of representation intended to express belief, judgment, experiences, reasons, information, or opinions"	Examine ideas Identify arguments Identify reasons and claims
Inference	"To identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypotheses; to consider relevant information and to educe the consequences flowing from data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation"	Query evidence Conjecture alternatives Draw conclusions using inductive or deductive reasoning
Evaluation	"To assess the credibility of statements or other representations that are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions, questions, or other forms of representation"	Assess credibility of claims Assess quality of arguments that were made using inductive or deductive reasoning
Explanation	"To state and to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological, and contextual considerations upon which one's results were based; and to present one's reasoning in the form of cogent arguments"	State results Justify procedures Present arguments
Self-Regulation	"Self-consciously to monitor one's cognitive activities, the elements used in those activities, and the results educed, particularly by applying skills in analysis, and evaluation to one's own inferential judgments with a view toward questioning, confirming, validating, or correcting either one's reasoning or one's results"	Self-monitor Self-correct

Source: Critical thinking skill definitions are from APA Report: Expert Consensus Statement on Critical Thinking. (ERIC ED 315-423)

GK-12 Fellow Nick Ballew

Cultivating critical thinking skills:
a condensed example to demonstrate the general lesson structure.



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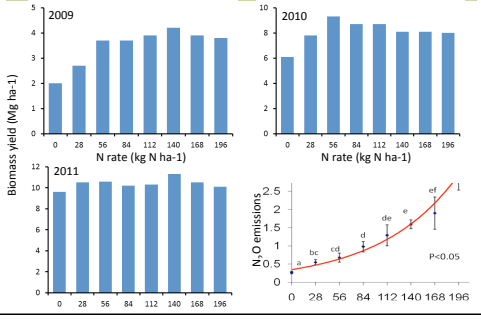


GK-12 Fellow Nick Ballew

Cultivating critical thinking skills:
the benefits of implementing this critical thinking lesson.

GK-12 Fellow Alycia Lackey

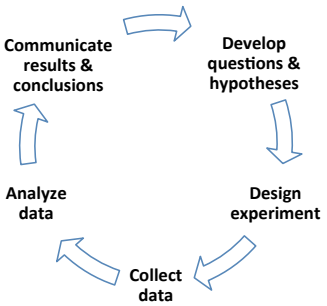
Alycia Lackey
Evolution, Ecology, & Behavior of Speciation

GK-12 Fellow Tomomi Suwa

Tomomi Suwa
Ecology and evolution of plant – rhizobia mutualism

Using real data in the classroom

Practicing the ENTIRE scientific process



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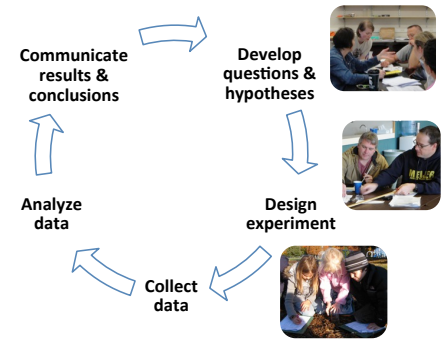

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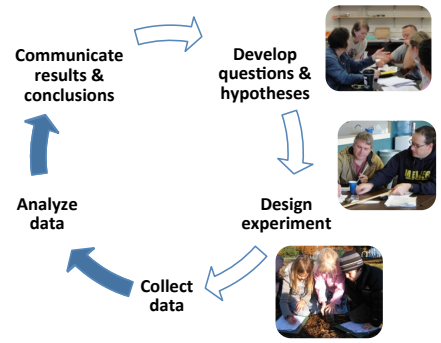
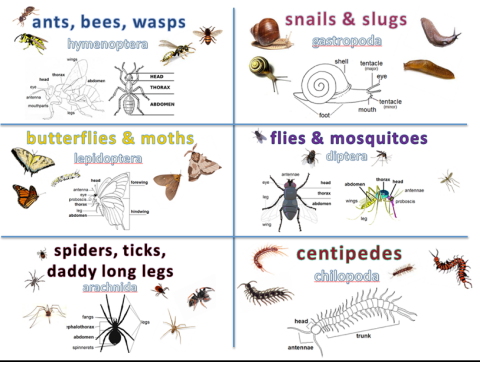


Using real data in the classroom

Invertebrates in our research plots

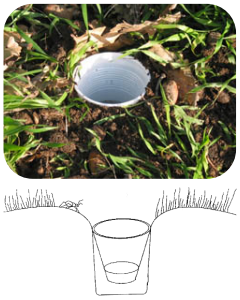


Using real data in the classroom

Trapping invertebrates

Sticky Trap

Pitfall Trap



Using real data in the classroom

Collecting data:
count & categorize

Sticky Trap

Pitfall Trap

Using real data in the classroom

Entering data:
Google forms

KBS GK-12 BEST Plot Data Form:
Invertebrate Biodiversity

Data Collection Method *

- [x] Sticky Trap
- [ ] Pitfall Trap

Prairie, unFertilized, unHarvested
Invertebrate orders present; remember: cursor or tab, NOT ENTER/RETURN
If data is not available for this plot, enter an "m" for missing in each field.

 # Ants, Bees, Wasps (Hymenoptera); Prairie, unFertilized, unHarvested *
enter 0 if none were present

Using real data in the classroom

Viewing data:
Google spreadsheets

KBS GK-12 BEST Plot Invertebrate Biodiversity spreadsheet

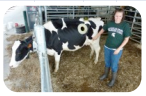
	Timestamp	Name of the Person Entering this Data: First Last	The Names of the People Who Recorded the Data	Your Teacher's Name (Mr., Miss or Ms. Lastname)	K-12 District & School	Block Code	Data Collection Method	# Ants, Bees, Wasps (Hymenoptera); Prairie, unFertilized, unHarvested	# Beetles & Weevils (Coleoptera); Prairie, unFertilized, unHarvested
10	1/25/2012 12:26:45	Kate Steensma	Hastings honors biology students	Marty Buehler	Hastings HS	Hastings: HHS1(8)	Pitfall Trap	1	117
11	1/25/2012 12:54:19	Kate Steensma	Hastings honors biology students	Marty Buehler	Hastings HS	Hastings: HHS1(8)	Sticky Trap	7	3
12	2/10/2012 16:58:12	Christine Nieman	Ms. Ratashak's Biology Class	Ms. Harbour	Vicksburg Env Labd	Vicksburg: VEL1(7)	Sticky Trap	2	0
13	2/10/2012 16:13:01	Christine Nieman	Ms. Ratashak's Biology Class	Ms. Harbour	Vicksburg Env Labd	Vicksburg: VEL1(7)	Pitfall Trap	2	1
14	2/10/2012 17:05:31	Alycia Lackey	Ash, Drew, Nathen	Mrs. Renner	Harper Creek HS	Harper Creek: HCH2(6)	Sticky Trap	0	0

Using real data in the classroom

Simplifying & Organizing data:
Automated spreadsheets

1) COPY AND PASTE ROWS OF DATA INTO ROWS 3-6

	Timestamp	Name of the Person	The Names of the People	Your Teacher's Name (Mr.,	K-12 District & School	Block Code	Data Collection Method	# Ants, Bees, Wasps	# Beetles & Weevils (Coleoptera)	# Bugs, Cicadas , Aphids	# Flies & Mosquitos (Diptera),
3	2/10/2012 15:58	Christine Nieman	Ms. Ratashak's	Ms. Harbour	Vicksburg Env Labd	Vicksburg: VEL1(7)	Sticky Trap	2	0	3	9
4	2/10/2012 16:13	Christine Nieman	Ms. Ratashak's	Ms. Harbour	Vicksburg Env Labd	Vicksburg: VEL1(7)	Pitfall Trap	2	1	0	0
5	2/10/2012 17:05	Alycia Lackey	Ash, Drew, Nathen	Mrs. Renner	Harper Creek HS	Harper Creek:	Sticky Trap	0	0	0	116
6	2/10/2012 17:13	Alycia Lackey	1st block	Mrs. Renner	Harper Creek HS	Harper Creek:	Pitfall Trap	2	1	0	3

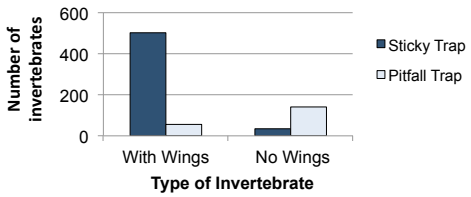


Fellow:
Christine Neiman

Using real data in the classroom

Simplifying & Organizing data:
automated spreadsheets

Types of Invertebrates	Number of Invertebrates Caught in Sticky Trap	Pitfall Trap
Wings	504	56
No Wings	36	143



Using real data in the classroom

Analyzing and Interpreting data:
multiple levels of skill development

- **Level 1**
  - Graph given, Interpret
- **Level 2**
  - Graph given, Redraw graph, Interpret
- **Level 3**
  - Summary data given, Draw graph, Interpret
- **Level 4**
  - More complex data given, Calculate summary data, Draw graph, Interpret

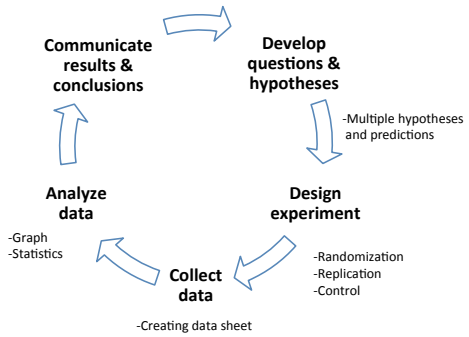
Using real data in the classroom

Practice analyzing & interpreting data:
benefits of our approach

- Varied skill levels
- Focus on skills that need development
- Authentic research experience

Using real data in the classroom

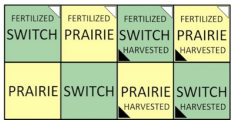
Practicing the ENTIRE scientific process



Using real data in the classroom

Questions to ask on BEST Research Network

- How does productivity vary among treatments?
- Does insect diversity differ among treatments?
- How will legumes be affected by fertilization?
- After several years, which treatments will have more nitrogen in the soil?



Using real data in the classroom

An example at the Middle School/High School Level

Using real data in the classroom

Do some habitats have more insects than other habitats?

Hypotheses | Design Experiment | Collect Data

Woods
Wetland
BEST Plots
Parking Lot

Using real data in the classroom

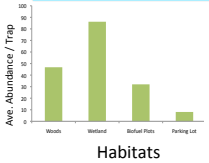
Collecting and Sorting Insects

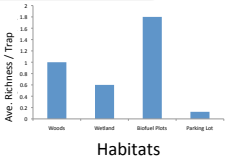
Using real data in the classroom

Data Analysis and Interpretation

Do some habitats have more insects than other habitats?

Habitat	# Sticky Traps	Total Insect Abundance	Total Insect Richness
Woods	10	468	10
Wetland	11	948	7
BeSt Plots	16	512	9
Parking Lot	6	130	2





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Benefits and Challenges

Fellows' Perspective

Benefits

- Comfortable with talking about our research
- Self-confidence
- Working in a collaborative team
- Become better scientists!

Challenges

- Unknowns in Science
  - Low germination
  - Weedy plots
- Data management in collaborative work
- Establishing long-term network within the framework of GK-12 funding period

Benefits and Challenges

Teachers' Perspective

Benefits

- Learn first hand what is new and ongoing in science research and have engaging conversations with fellows.
- Increased enthusiasm for learning and teaching science, while changing the way teachers think.
- Most teachers are comfortable with science content. Many are able to perform "cookie-cutter" science labs. With the help of fellows, mentoring teachers become proficient using inquiry and relax with the unknowns.
- Teachers need more exposure to these relationships not less as the next generation of science standards calls out for greater student understanding of evidence and ability to reason claims.

Challenges

- Few are comfortable with the uncertainty of inquiry
- Incorporate BEST plot project in school curriculum K-12

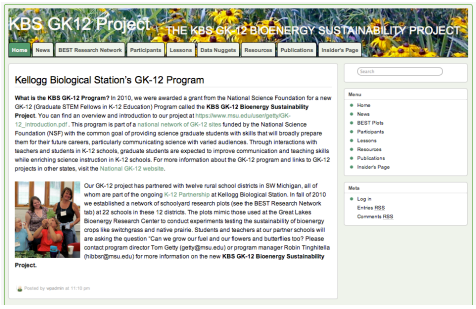
Benefits and Challenges

Student and District Perspective

- Students learn to see scientists as accessible people and have opportunities for adding to the science community as they begin to see themselves as scientists.
- Students gain renewed interest in "their" science through new inquiry lessons and heighten their ability to state claims, give evidence and reasons.
- School districts find GK-12 to be a time worthy investment and benefit from the newly generated curriculum, added materials, time spent in the community.

Contact us

Project Materials Available: kbsgk12project.kbs.msu.edu



Building Long-term Research Projects and Collaborations

MICHIGAN STATE UNIVERSITY | GK BS12 Bioenergy Sustainability Project

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Leadership: Tom Getty (PI) and Robin Tinghitella (Project Manager)