Opportunities to Learn Scientific Literacy
(What QuarkNet Data Show)

Marge Bardeen
QuarkNet
mbardeen@fnal.gov
QuarkNet, a Partnership!

Creates a long-term “research community”

Develops links between experiments & classrooms

Engages students in scientific investigations

Develops scientific literacy

This project is supported in part by the National Science Foundation and the Office of High Energy Physics, Office of Science, U.S. Department of Energy. Opinions expressed are those of the authors and not necessarily those of the Foundation or Department.
QuarkNet

Program Design Models Research Experiments

Distributed effort with central management
Each center strategy matches local needs & resources.
The whole $\geq \sum$ (parts).
Communicate findings across centers.

---

Physicists are mentors & colleagues.
Teachers are researchers & facilitators in classrooms.
Students are researchers.

quarknet.fnal.gov
Scientific discovery is a journey, not an event!

1. What we know
2. Questions we ask
3. Tools we build and use
4. How we know
5. What we learn
Scientific discovery is a journey, not an event!

1. What we know
2. Questions we ask
3. Tools we build and use
4. How we know
5. What we learn
Activities from QuarkNet . . .

that engage high school students.*

Data in Masterclasses
Data in Investigations
Research Experiences

*These kids are already interested in science.
What Students Gain

A broader frame of reference for science:

How scientists discover new knowledge.
How they talk about their work.

M. Bardeen, ICHEP, Melbourne, July 2012
How We Know: Data from QuarkNet

Pre- Post-Tests
Teacher & Student Surveys
Scientific Poster Review
Concept Maps
Engaging Students in Science

Data for Students

M. Bardeen, ICHEP, Melbourne, July 2012
Hands-on analysis with real data and you.

U.S. Masterclass
Tips for Effective Masterclasses

- Correlate data to something real.
- Bring students into your environment.
- Tour, visit research areas.
- Talk about your experiences, personalize.
- Give interactive presentations at students’ level.
- Focused, short, engaging
- Share useful examples & show relationships to everyday life.
- Answer questions . . . at their level.
- Some preparation at school helps.

M. Bardeen, ICHEP, Melbourne, July 2012
Guided Student Investigation

Online Investigations with I2U2
Guided Student Investigation

Online Investigations with I2U2

M. Bardeen, ICHEP, Melbourne, July 2012
Guided Student Investigation

Online Investigations with I2U2

M. Bardeen, ICHEP, Melbourne, July 2012
Guided Student Investigation

Online Investigations with I2U2
Guided Student Investigation

Online Investigations with I2U2
Explore an Event
Explore an Event
Explore an Event
Explore an Event
Cosmic Ray Studies

Forbush
Tips for Effective e-Labs

A 2-3 day teacher workshop is essential for effective classroom implementation.

- Let them experience the e-Lab as their students will.
- Correlate data to the real detectors.
- Provide interactive, engaging presentations.
- Background material
- Answer questions at their level of understanding.
- Provide time for teachers to talk about teaching strategies.

M. Bardeen, ICHEP, Melbourne, July 2012
Research Experiences

QuarkNet Research Team

4 students
1 teacher
6 weeks
Engaged in all aspects of research
Students become more interested in science, in particular in physics.

What students learn:

- Iterative nature of science
- Collaborative nature of science
- How past informs present in science

QuarkNet has taught me that patience, common sense, and maturity will often serve you better than a book ever will. Through working on intellectually challenging activities, such as testing pods, programming software, and writing webpages, we learned that mistakes are not dead ends, but simply stepping stones.

M. Bardeen, ICHEP, Melbourne, July 2012
Tips for Effective Research Programs

Students become part of your research team:

- They experience all aspects of the scientific process.
  - Troubleshooting
  - Calibrating equipment
  - Use of journals or logbooks
  - Why data are analyzed in a particular way
  - Importance of communicating ideas & results

- They report findings.
  - Presentations
  - Posters
  - Abstracts & papers

- They work least 4 weeks.

M. Bardeen, ICHEP, Melbourne, July 2012
What’s Effective?

Providing authentic experiences!

Working directly with students (& teachers)

In the short term, you create interest

In the longer term, you build understanding and relationships, scientific literacy
What Students Gain

A broader frame of reference for science:

How scientists discover new knowledge.
How they talk about their work.
QuarkNet Center Success Factors

- Strong teacher leader
- Strong mentor
- Regular meetings
- Meaningful activities
- Address classroom implementation
- Staff support & follow-up
- Stable participant base
- Address professionalism
- Establish a learning community
- Additional funding
Particle Physics Outreach to Secondary Education

Marjorie G. Bardeen, K. Erik Johansson and M. Jean Young

Annual Review of Nuclear and Particle Science
2011.61:149-70
(nucl.annualreviews.org)