POLAR SCIENCE AND ENGINEERING...

A Model for NGSS Practices
US Ice Drilling Program

Strategic Planning for Science and Drilling Technologies

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Today’s Focus: The “Practices”

Processes of building and using Core Ideas to make sense of the natural and designed world.
Key Messages

• Integration of engineering concepts and processes

• Parallel practices; different outcomes

• Emphasis on how scientists and engineers work together and communicate results
Our Question:

How can we as educators effectively help students to distinguish these practices?
Reflecting on an Antarctic adventure, with interactions between scientist and engineers
A key question being asked by scientists is,

“How can we predict future climate changes, and their impacts, to empower decisions today”
What we know:

Earth’s system of interacting systems influences long-term climate patterns
What we need to know: data from the past.

We started by looking at strategies others have used...
Sediment core record showing glacial cycles

2 million years age

Warm, little ice

Great long record, But low resolution + Complicated proxy

cold, lots of ice

Today

Huybers (2006)

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The moving atmosphere carries environmental evidence to the polar ice sheets.
The evidence becomes archived in ice sheets.

- Falling Snow
- Surface
- Firn (*old snow*)
- Firn-to-ice transition 60 to 110 m
- Ice with bubbles of atmospheric gas

- Isotopes
- Pollutants
- Sea salts
- Dust
- Radioactive fallout

- CO2
- CH4

- Volcanic Tephra

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High accumulation layers yield high resolution ice core data at WAIS Divide, Antarctica
Drilled to 3400 m deep
(more than two miles)
Recent Core From WAIS
Precisely Dated
Annual resolution to 30,000 years

Data from T.J. Fudge

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CO₂ and temp, rising together 18 K yrs ago
Scientist: A really interesting period-I need more ice!

More ice core data is needed from this really funky event
Scientist: Can we drill another core?
Engineer: Sure, but it took 4 seasons and $$ to get to that depth!
Engineer: What about drilling out the side of the hole instead?
We can block the hole to deviate out the side. That’s worked before-

18k event
Scientist: No, I need to measure stuff down the entire borehole length
Instruments will need to get past the 18K event depth...
Sample Borehole “Logging” Tools

- Optical
- Seismic
- Sonic Velocity
- Acoustic

Temperature

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Engineer: So what about going out the uphill side of the borehole so gravity pulling the tools into deviations is not a factor?
Tools with still pass by the replicate hole, - Yikes, this has never been done before!
Science Goal: cores parallel to the main hole to duplicate results from depths of great interest-

Engineer: That’s going to require a whole new kind of drill !!

Audience: What kind of questions would you want to ask to define the drill the scientists need?
DISC Drill Modifications Done

Existing Components:

Pump/Motor Section

Instrument Section

Anti-torque Section

New Components

Cutter

Reduced Diameter Core Barrel

Reduced Diameter Screen Barrels

Actuator Module

Actuator Module

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• Actuators Force Cutters to High-side of Parent Hole.
• Direction and Magnitude of Force via Surface Command
• Real-time Adjustments On-Board Controller
• Ascend/Descend to Deviate Over ~25m.
Prototype Testing Accomplished

Actuator

Coring Head  Milling Head

Broaching Head

Deviation Cutter

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2011-12 Field Test: Problems identified

Summer 2012 - evaluation and redesign

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2012–13 season
A Huge Success!

5 deviations were completed from at four different depths

• All goals were met
• 284m of core were recovered
• First time an ice borehole has been deviated on the high side!

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The 18k event was recovered not once, but twice: Stay tuned for analysis of the event!
Audience Question:

What processes or actions did you observe the scientist and/or engineer using?
NGSS Practices-how’d we do?

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
Activity: Drilling Back Through Time

1) Prepare your students

2) View the movie

www.youtube.com/user/USIceDrillingVideos

3) Check off each step as you hear it modeled by a scientist or engineer

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Resources

Activity:

US Ice Drilling Program
- [www.icedrill.org](http://www.icedrill.org)
- [www.climate-expeditions.org](http://www.climate-expeditions.org)
- Linda.m.morris@dartmouth.edu

NSTA Webinar (will be archived)
- February 27, 2014:
  Jihong Cole-Dai, Jay Johnson, Linda Morris
  “Polar Science and Engineering”