Phenomenal Tools for MSS Chemistry and Physics Instruction

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What will we do today?

• Discuss ideas of Project Based Learning and Student Engagement
• Engage in supporting students’ modeling practice
• Explore examples of the teacher-developed units and MSS-aligned assessment items
Goals of Crafting Optimal Learning in Science Environments project

Support teachers in the development of learning environments that enhance optimal learning moments for students in secondary science physics and chemistry classrooms.

Learning environments will:
• Use project-based learning design principles
• Focus on figuring out phenomena or solutions to problems
• Integrate core ideas, crosscutting concepts and scientific practices to make sense of phenomena- 3D learning
How can I increase student engagement in my classroom using PBL Units with 3D learning?
PBL units provide a framework for enhancing student engagement

What are the features of a PBL unit?

• Meet important learning goals
• Pursue solution to a meaningful question
• Explore the driving question by participating in scientific practices
• Engage in collaborative activities to find solutions
• Use learning tools and other scaffolds to help students participate in activities normally beyond their ability
• Create artifacts- tangible products- that address the driving question
3D Learning in K-12 Framework and NGSS

Meet important learning goals

Disciplinary Core Ideas

Scientific & Engineering Practices

Crosscutting Concepts

Performance Expectations
PEs and learning goals

Electric Motor- Physics unit

**HS-PS3-1** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

**HS-PS2-5** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

**HS-PS3-3** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*
PBL lessons are connected by a driving question. They build towards a PE or set of PE’s that gives students a purpose for learning.
3-D Lesson level learning goals build toward the PE’s

- Students will observe and ask questions about how the electric and magnetic components work together as a system in an electric motor.
- Students will investigate the interaction of electric and magnetic components of simple and more complex electric motors to determine similarities and differences.
- Students will develop models to explain how energy changes through a system in a motor while the total energy is conserved.
- Students will plan and carry out an investigation to determine the causal relationship between the kinetic energy produced and strength of the magnetic field.
- Students will develop models to explain the interaction between the rotating coil and the stationary magnet using data from their investigation of electromagnets.
Why build towards a performance expectation(s)?

Establish Coherence

• Lessons fit together coherently
  • Science ideas build upon each other so that they become more sophisticated over time
  • Lessons link together

• Different practices are used together with disciplinary core ideas (sometimes from different disciplines) to explain phenomena.
• Different crosscutting concepts are also used in the explanation of phenomena.
Pursue solution to a meaningful question

Start with a Driving Question

How can I make the “best” (most efficient) electric motor?
What makes a good driving question?

• **Feasible**- Students should be able to design and perform investigations to answer the question and explain phenomena.

• **Worthwhile**- Questions should deal with rich content and practices.

• **Sustainable**- Questions should sustain students’ interest for weeks as they find solutions to the driving questions.

• **Meaningful**- Questions should be interesting and valuable to learners.

• **Ethical**- Exploring the question should not lead to harm of the environment or living creatures.
Anchoring Events

• Provide students with common experiences from which they can find meaning and value, and which helps them make connections to new ideas explored.

• Present meaningful contexts in which learners can attach the ideas explored in the project.

• Used at the beginning of and throughout a project to support students in critically reflecting on their initial questions and as well as asking new questions.
Pursue solution to a meaningful question

Why is experiencing phenomena important?
What does PBL look like in the Classroom?

How can I make the “best” (most efficient) electric motor?
Question Formulation Technique

Part 2:
- Change closed-ended questions to open-ended questions.
- Categorize questions.
- Prioritize Questions.
- Reflect.
Draw Initial Models

Sub Question

DQ: How can I design a vehicle to be safer for a passenger during a collision?

What happens during a vehicle collision?
Classroom Activities

Driving Question Board

DQ: How can I design a vehicle to be safer for a passenger during a collision?

Factors of a Collision

Materials

Design

Activity Summary Board

<table>
<thead>
<tr>
<th>Question</th>
<th>Activity</th>
<th>Big Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1 - Take apart a toy model</td>
<td>- Coil, Metal Rings, Magnets, Axle, Gear, Wheels</td>
<td></td>
</tr>
<tr>
<td>Activity 2 - Build a simple electric motor</td>
<td>- Electricity flows in a coil</td>
<td></td>
</tr>
<tr>
<td>Activity 3 - Magnetic field around coil: use “Every magnet has a north pole”</td>
<td>- Change the field strength of the coil</td>
<td></td>
</tr>
<tr>
<td>Activity 4 - Magnetic field lines in coil: a stationary magnet</td>
<td>- Electricity flows in a coil</td>
<td></td>
</tr>
<tr>
<td>Activity 5 - How do we measure the magnetic pull on a toy motor?</td>
<td>- Electromagnetic forces</td>
<td></td>
</tr>
<tr>
<td>Activity 6 - Build Electric Motors</td>
<td>- Create a magnetic field</td>
<td></td>
</tr>
</tbody>
</table>

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Model Rubric

Components:

• Objects involved in the electric motor lifting a mass
• battery
• part of the motor
• mass- paper clip

Relationship between Components:
Sage Models

Exercise I: Basic model showing relationships between potential energy relationships in electric motor system.
Tangible artifacts

Students make design change to the motors and compare efficiency.
3-D Assessment

Sam tried to build a do-it-yourself toy. He took a single AA battery and some copper wire. He made a coil from the copper wire and connected the ends to the battery (see pictures below). After the toy was built and connected, Sam noticed that a steel paper clip, which was on the table next to the toy, started moving towards it.
PEs and learning goals
Evaporation- chemistry unit

HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy of particle motion and energy of particle position.
Pursue solution to a meaningful question

Driving question
Evaporation - chemistry unit
When I am sitting by the pool why do I feel colder when I am wet?
“Figuring Out” vs. “Learning About”

• **Explanatory ideas** are important so that students are figuring out phenomena and not just learning about facts and details.

• **Science and engineering practices** build explanatory ideas.

- Explore Scientific Ideas
- Make Sense of Phenomena
Explore the driving question by participating in scientific practices
Engage in collaborative activities to find solutions
Collaborative activities
Use learning tools and other scaffolds to help students participate in activities normally beyond their ability.
Learning tools
Evaporation - chemistry unit
Concord Consortium simulation
Tangible artifacts
Evaporation - chemistry unit
before:

Reason why we cool down as particles leave:

liquid evaporated b/c of the heat from our hands. The heat transfers from the hand to the paper.

after:
An excerpt from a model on Google docs

Our models represent the water molecules leaving the skin helping answering the question.

You become colder as the water molecules leaves your body and takes some of your body heat and then goes into the air. Causing both the potential, body heat and water molecules to leave your body.
Final Model created by a pair of students
(Will Paddock, East Lansing High School)
The reason why we are colder when we are wet than when we are dry is because the heat from our bodies transfers to the water molecules, leaving us colder. The water molecules speed up, evaporate, and spread out around the atmosphere, leaving us with no heat energy, making us colder when we are wet.
Summary
What are the features of a PBL unit?

• Meet important learning goals
• Pursue solution to a *meaningful question*
• Explore the driving question by participating in scientific practices
• Engage in collaborative activities to find solutions
• Use learning tools and other scaffolds to help students participate in activities normally beyond their ability
• Create artifacts – tangible products – that address the driving question
Questions?

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To download materials-

Evaporation storyline:  https://goo.gl/JyiiGh
Forces and motion storyline:  https://goo.gl/9lvpGc
Modeling practice handout: