**Introduction**

The purpose of this project is to describe two specific strategies informing the design of reformed materials useful in a variety of settings, warm-ups and scaffolding, and link the strategies with key findings in education research that inform their use. We initially utilized these strategies during reform of the lab component of an upper level majors’ geology course (Introduction to Mineralogy). Subsequently, we successfully adapted these strategies for modification and design of materials in other courses and contexts.

For each strategy, we focus here on:
1. critical aspects of the strategy,
2. rationale behind this strategy from the education research literature,
3. examples of reformed materials from Mineralogy lab,
4. feedback from TA and students on impact of reforms, and
5. how we applied these strategies in other settings.

**Impact of warm-up activities in Mineralogy based on feedback from TAs and students**

**Before warm-up (Fall 2008)**

- Students struggled with and HATED doing the lab exercise associated with the end goal.
- TAs HATED teaching the lab.
- The exercise had too many conceptual leaps for students (one MAJOR conceptual CLIFF!).
- Students lacked a toolkit/strategies to effectively complete the exercise (and learn from it).
- Student frustration seemed to lead them to focus on getting a "correct" answer, not to conceptual understanding.

**With warm-up (Fall 2009)**

- Students were more active and engaged with the lab exercise.
- Students discovered key concepts themselves (had ownership of their own learning).
- Students produced something they could be proud of (a lab write-up).
- Students discovered key concepts themselves and developed an understanding of the exercise (and its purpose).
- Student ownership and understanding of the exercise increased.

**Scaffolding: Temporary structures that support learning**

**Goals**
- Students should be able to identify symmetry elements and crystal systems in an un-adorned 2-D crystal model, and link symmetry elements with their standard symbols.

**Critical Aspects**

1. Designed with respect to student prior knowledge and end goal.
2. Provides explicit structure and guidance allowing students to make sense of new material in small steps.
3. Purposeful content-based scaffolding.
4. Design is integrated into what learners already know (content integration).
5. Planning assistance in advance for students in problem solving.
6. Making explicit what are often implicit and automatic (or assumed) steps taken by experts in problem solving.
7. Emphasize the ideas of:
   - Conceptual understanding.
   - Own ownership of the strategy, taking responsibility for their own success.
   - Critical aspects to scaffold.
   - Critical aspects to scaffold.

**Starting point**

- Students may be at different knowledge levels.
- Expert-like activities are inappropriate.
- Students have different skill levels.

**Input:**
- Visualize the main crystallographic axes and link them to the crystal system.
- Identify the crystal system and crystal system and determine the kind of symmetry they are dealing with.
- 3-D labeled crystal model, and link symmetry elements with their standard symbols.

**Output:**
- Key finding: Students learn a new concept.

**Exercise analogy:** an activity that prepares you for later, perhaps more intense, activity (mentally, physically)

**Using “warm-ups” and designing scaffolding:** transferable strategies for reforming upper level majors’ lab components in Geology

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**Using “warm-ups” and designing scaffolding:** transferable strategies for reforming upper level majors’ lab components in Geology

1. **There are things you may already be doing, and can tweak to maximize the positive impact.**
2. **KIT? it’s much closer to implement if you have KITs in mind what should students be able to do?**
3. It’s fairly straightforward (not a huge time commitment) to create or modify materials to introduce scaffolding or warm-ups:
   - Create the steps students should go through to do a task, and what they should able to do at each step.
   - Develop a simple and clear break-down of major concepts in which students did something meaningful using the microscope to answer questions and observe different mineral properties.
   - Engage group and class discussion to elicit student thinking, and link to goals for the day.
   - Review general concepts to support connections between current task and other students already know how to do.

Additional examples from other courses: ask us to explain!