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PRACTICE, PRACTICE, PRACTICE: BUILDING ONLINE TOOLS TO HELP STUDENTS MASTER SKILLS

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Introduction

I teach Mineralogy: the subfield of Geology concerned with minerals. One of the most important skills that students must master in this course is visual identification of minerals. They must be able to pick up a rock and say, "This contains quartz, alkali feldspar, plagioclase feldspar, and muscovite."

This is a hard skill to master. Minerals vary widely in physical characteristics: quartz, for example, can be clear, white, pink, purple, yellow, orange, or black – but it's still quartz. Serpentine can look like the back of an anaconda or the hair of a just-woken toddler, but it's still serpentine. So students must see many examples of each mineral, in order to be able to identify them. And, as with any skill, it requires repeated practice in order to master. It's not enough that students see many samples of serpentine: they must see many samples of each kind – the snake type and the toddler-hair type.

Designing a class that provides those opportunities is challenging, for several reasons:

1. **Not enough class time**. We have many concepts to cover – in addition to this one skill. Even if we spent all our class time practicing mineral identifications, students wouldn't get enough practice to master them. And we can't spend all our time on it.
2. **Not enough examples.** Bryn Mawr College has an excellent mineral collection, but, to really master visual identification of scapolite, students need to see *dozens* of samples of scapolite. We have four. Most schools have none.
3. **Feedback is too slow**. In a traditional Mineralogy class, students look at unknown samples of minerals in lab, write down the names of each ("Sample 7 is quartz"), then turn those in. They're graded, and handed back next week in lab. By then, the students have forgotten what Sample 7 looked like, so the correction "No, it's feldspar," means nothing. In essence, the students have practiced *wrong*.
4. **No chance to re-think the problem**. Even if a student does remember Sample 7, they now know the answer. They don't have to go back and reassess their thinking, revise it, and try again. They don't have to think through the problem.

I brought this set of challenges to two different pedagogy seminars supported by the Teaching and Learning Institute (TLI) at Bryn Mawr College and to my partnerships with two students, Mia Chin (BMC '12) and Samyuktha Natarajan (BMC '15), both part of the TLI student consultant program. In conversation with these colleagues, I was able to refine a set of online tools that have become invaluable in my teaching.

While I developed these tools specifically for a Mineralogy course, they're applicable to any class where students must practice visual identification: ecology, art history, anthropology, etc.

Instant Feedback Practices (IFP)

An IFP is an online quiz, built using the Moodle “Quiz” feature. After class, students log onto Moodle, and select that night’s IFP. There is one question per page – usually a photo of a mineral, and a field where they can write the mineral’s name. They name it, and click Submit. Moodle tells them instantly if they got it right (instant feedback). If they got it wrong, Moodle doesn’t tell them the right answer – it asks them to try again. The students may try as many times as they like, without penalty, to get the right answer. They get credit for completing the quiz – it is not a test. It’s just practice.

This type of tool allows students to repeatedly practice minerals throughout the semester. We begin with the most common minerals first. Then, as we add more throughout the semester, I include a few of the most common ones into every night’s IFPs. As a result, they practice the most common minerals, every night, for the whole semester – essentially, retesting. Numerous studies have shown that practice is most effective when the student practices at multiple-week intervals (“the spacing effect”).

IFPs also allow me to have the students practice other skills. I give them mineral formulas some nights, and ask them to name the minerals that go to them. Or videos of minerals under optical microscopes – and ask them to name the optical process that the video illustrates. Or new terms – and ask them to define them.

By design, then, IFPs are low-stakes, low-time commitment opportunities to practice the skills that the students are expected to master. By requiring students to complete a 15- to 30-minute IFP each night after class, I provide them with systematic, continuous, low-stress practice throughout the semester.

IFP development benefited directly and continuously through collaboration with TLI’s student consultants. My two student consultants previewed IFPs for me as they were developed, worked with me on building logical sequences for the introduction of ideas, and solicited feedback from students on how the IFPs were working and how they could be improved.

Scaffolding

I also often organize IFPs into sequences designed to help students gradually build a skill. For example, here is a sequence of IFPs used to help students gradually become familiar the mineral formulas they must master:

- Day 1 – IFP questions are multiple-choice. I give students a formula, and ask them to pick the mineral it represents from a list of possibilities. (This is easy, as we talk in class about the rules for reading a formula).
- Day 2 – IFP questions are multiple-choice. I give students a mineral name, and ask them to pick the formula from a list. (This is slightly harder, because students must remember the rules and the formula).

- Day 3 – IFP questions are short answer. I give students a mineral formula, and ask them to type in the name of the mineral it represents. (This is slightly harder, because students don't have the list of minerals right there in front of them).
- Day 4 – IFP questions are short answer. I give students a mineral name, and ask them to type in the formula. (This is the hardest, because they must remember the whole formula).

In this way, I gradually lead students through mineral formulas, practicing in increasingly difficult ways.

The TLI student consultants were particularly helpful during this phase of development: I would often test out the sequence on them ahead of time, rearranging the order after receiving their feedback on the progression of ideas.

Monitoring Student Progress

At the end of each IFP, I ask students to fill out a short online questionnaire, consisting of a thumbnail of each image that was in the IFP, with radio buttons asking the students to rank how difficult that image was for them to identify. This assists students with metacognition by prompting them to recall the identifications they just practiced – and it tells me which images the whole class ranked as challenging. I can then, at the start of next class, pull those images up on the projector, and we can all talk about them.

This aspect of IFPs particularly benefited from discussions with my colleagues in TLI's new faculty seminar, where several sessions of brainstorming lead to a smooth process for me to identify were students were struggling.

The overall process, then, looks like this:

1. Students come to class, learn the skill they will be practicing.

2. Students go home, complete the IFP to practice the skill.

3. Students fill out the questionnaire about how difficult the IFP questions were.

4. In the next class, I discuss the images that students ranked most difficult.

5. Students go home, complete the next IFP. Normally, the IFPs will be of gradually increasing difficultly, but I can adjust the pace of the class and difficulty of subsequent IFPs, according to whether the questionnaires show students are finding material too easy or challenging.

6. Students can return to previous IFPs to practice throughout the semester; for example, before an exam.

Moodle Trays

Of course, in the field, students won't be identifying minerals based on photos. Usually, they will have to do it using a rock they just picked up. So it's important for them to practice these skills using actual rocks and minerals.

For this, I designed the Moodle Tray: essentially, an IFP that students do in class. I form the students into teams, bring them to the computer lab, and give each team a tray of samples. They log onto Moodle and choose the appropriate Moodle Tray assignment (I build them using the Lessons function in Moodle). In the activity, the students click on the sample number they're about to identify, and are taken to a page that asks them to name Sample X. They name it, click submit, and are told immediately if they got it right or wrong. Again, if they get it wrong, they are not told the right answer, and must instead re-think it. Again, there are no penalties for getting it wrong – it is simply practice. Again, I scaffold the samples so they are practicing progressively harder examples. And, again, I ask them to assess how difficult each was – and we, as a class, discuss them.

Unlike IFPs, though, Moodle Trays provide an opportunity for group practice. Students may complete the trays in teams of 2 or 3, giving them a chance to discuss each sample with each other.

My work with Moodle Trays benefited enormously from my collaboration with TLI student consultants. I put the students in groups throughout the semester, assigned them Moodle Trays, then asked the student consultant to observe and take notes on group interactions as they worked through the trays. Together, we would then test out new group arrangements to find groups that worked best together. We finally used the semester's worth of observations of group interactions over Moodle Trays to define the end of semester project groups.

Student Feedback

I have implemented IFPs the last two times I taught Mineralogy. The students gave very positive feedback on them, often requesting more in class to supplement whatever they were struggling with (Amphiboles vs. Pyroxenes, for example.)

Example student comments from mid-semester feedback on the online IFPs:

- "IFPs help me because I can take them over again if I want to study."
- "[IFPs are] helpful because they immediately give us feedback."
- "I love IFPs. The repetition really helps me learn."
- "IFPs really help a lot and the most for me."
- "More IFPs!"

Example student comments from mid-semester feedback on the Moodle Trays:

- "Most useful things anyone ever thought of."
- "The tray IDs were a huge helper"

- "I love the trays!"
- "I like to revisit the trays … 10X or 100X!"

Right now, I am continuing to test the effect that IFPs have on long-term retention. Each Fall, I retest my previous Fall's students on mineral identification, to assess how well they retained the skill. This will require several more semesters worth of data, given the small number of students involved.

The blended-learning approach of using online tools to help students practice is useful for a wide variety of skills. It is particularly suited for visual identification skills (e.g., thin section photomicrographs, fossils, reading structure diagrams, rock descriptions, identifying geomorphic landforms, etc.), and for skills in the lower parts of Bloom's Taxonomy (e.g., memorizing mineral formula).

Conclusion

Bryn Mawr's Teaching and Learning Institute and the Blended Learning Initiative were instrumental in developing, refining, and using these online tools that have dramatically improved the quality of instruction in my Mineralogy course. In the TLI seminars for new faculty and Teaching with Technology, I was able to bounce ideas and designs off fellow teachers, who provided multidisciplinary perspectives on how these tools could be improved. And the TLI student consultants acted as guinea pigs, sources of unique student perspectives, and as conduits through which the students in my class could provide feedback to my on the online tools.

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