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THIN SECTION PROBLEM SOLVING ASSIGNMENTS: AN INQUIRY-BASED ACTIVE-LEARNING STRATEGY FOR UNDERGRADUATE EARTH SCIENCE STUDENTS

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INTRODUCTION

I have been teaching mineralogy-petrology courses at Western Oregon University (WOU), a four-year liberal arts institution, for 14 years. I inherited a single Earth materials course called "Rocks and Minerals", which focused on hand-sample study of minerals and mineralogy concepts, with limited coverage of petrology. This course featured a standard lecture format and was heavily memorization based. Also, the program lacked petrographic microscopes, so it was not possible to teach microscopy. In developing the Earth materials curriculum for the broad-based Earth Science major offered at WOU, I have wrestled with how to teach the relevant aspects of mineralogy, microscopy, and petrology in the absence of a yearlong sequence that is commonplace in more traditional geology degree programs.

In 2001, I began an NSF-CCLI project to revise the Earth materials curriculum at WOU. The primary objective was to develop an active, inquiry-based approach to teaching mineralogy and petrology within the context of a broad-based undergraduate Earth Science degree. The CCLI grant and subsequent institutional funding have supported the acquisition of student petrographic microscopes and scopes with digital imaging systems. With this equipment, I have established a mineralogy-petrology curriculum that emphasizes thin section study and is much more inquiry-based. This curriculum includes development of a lab-driven microscopy course and full-scale revision of the petrology course. As well, an active-learning strategy that engages students in the study of rocks and minerals has been implemented.

REDESIGNING THE EARTH MATERIALS CURRICULUM

To overcome the issue of limited credit hours, the Earth materials curriculum was renovated to include a lab-based Petrographic Microscopy course and an integrated lecture-laboratory Petrology course.

Petrographic Microscopy Course: Focuses on student skill development in using a microscope to identify basic rock-forming, accessory, and alteration minerals in thin section. Emphasis is on the optical properties that are needed to identify minerals.

Petrology Course: Integrated lecture-laboratory course covering broad range of mineralogy-petrology content. Focus is on the study of rocks; mineralogy concepts are presented on "need-to-know" basis.

These courses are framed around an inquiry-based pedagogy that is designed to actively involve students in the scientific process and move away from passive-recall teaching methods. This learning strategy consists of a series of "Thin Section Problem Solving" assignments that begin in the Microscopy course and continue through the Petrology course.

"NUTS AND BOLTS" OF THIN SECTION PROBLEM SOLVING ASSIGNMENTS

The central idea behind "Thin Section Problem Solving" assignments (TSPSAs) is for students to use thin sections as a geologic data source for conducting authentic scientific investigations. For each TSPSA, students are provided with a thin section (and in most cases, a corresponding hand sample). As depicted in Figure 1, students study the thin section and hand sample, make observations, identify a scientific problem/question, propose a working hypothesis, collect data with computer-based technologies to test the hypothesis, and defend their results in a class-wide discussion session and written reports. Students are instructed to test the hypothesis using observations and data that can be taken directly from the sample. For each assignment, students prepare a short paper (no more than 2 pages) and give a brief presentation to the class (5-7 minutes with 3-5 minutes for discussion). Class members are encouraged to question their student colleagues. Presentations and class-wide discussion sessions require a two-hour class period.

Students are first introduced to TSPSAs as part of the take-home final in the Microscopy course. TSPSAs are continued in Petrology: three over the course of the 10-week term and one as part of the final exam. In Petrology, TSPSAs augment more traditional laboratory exercises and are aligned with course content.

TSPSA #1: Using set of different rock types, students are guided to think about what geologic conditions and/or environment sample formed in.

TSPSA #2: Using set of distinct plutonic and volcanic rocks, students define their own problem. Samples from an earlier description and classification exercise.

TSPSA #3: Using set of metamorphic rocks, students are instructed to determine metamorphic conditions based on textures and/or mineralogy.

TSPSA #4: Conducted as a take-home portion of the final exam. Students assigned one of two andesite samples and encouraged to consider origin of sample in context of a case-study activity conducted during term.

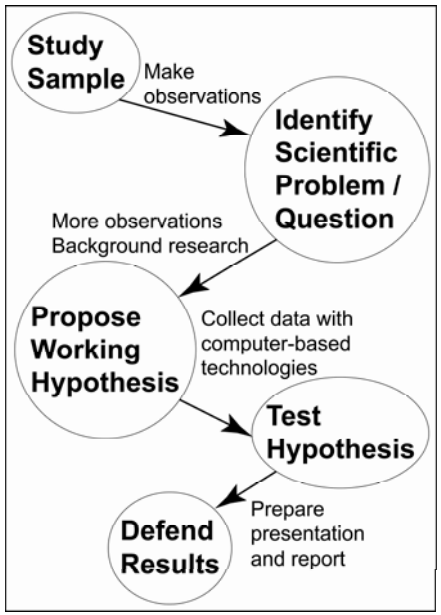
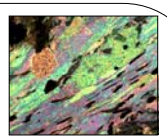


Figure 1: Schematic representation of the process that students undertake when completing a Thin Section Problem Solving Assignment.

ASSESSMENT OF STUDENT WORK



Evaluate the following:

- **Geologic problem**
  - ✓ Rate quality of problem
  - ✓ How well does student address specific problem?
- **Hypothesis to address problem**
  - ✓ Does student propose a workable hypothesis to address geologic problem?
- **Tests of hypothesis and interpretations**
  - ✓ Use data and observations directly available from thin section
  - ✓ Support interpretations using textural features and/or mineralogy that are observed in sample
  - ✓ Provide relevant data and observations (e.g., mineralogy, modes, textural relations, and lithology)
- **Impressions of paper**
  - ✓ Writing style and organization
  - ✓ Use appropriate figures to support descriptions
- **Presentation**
  - ✓ Rate overall quality, including organization, figures, readable slides, and style
- **Class Participation**
  - ✓ Was student engaged in learning process as demonstrated by asking questions of student colleagues?

ISSUES & CHALLENGES

While TSPSAs are designed to actively engage students in doing science, there are some pitfalls to this strategy.

- **Challenging endeavor for students**
  - ✓ Based on instructor perception, appears to challenge students
  - ✓ Requires quite a bit of out-of-class time for students to complete
- **Some students struggle with identifying a scientific problem or question**
- **Some students have trouble developing a testable working hypothesis**
  - ✓ In some cases, propose tests that are not readily solvable given sample/materials that are available to them
- **Class-time requirement**
  - ✓ Three, 2-hour class periods for presentations and class-wide discussion sessions
  - ✓ Grading can be quite time consuming

POSITIVE ATTRIBUTES

Despite these challenges, I am optimistic about the long-term potential of TSPSAs as a strategy to engage students in the learning process and move from a fact-based teaching method to a process-oriented model.

- **Conduct authentic scientific investigations**
- **Enhance geologic problem-solving skills**
- **Develop technology skills**
  - ✓ Use petrographic microscopes and digital cameras interfaced with computers
  - ✓ Employ software to collect images and prepare multi-media presentations
- **Present results in both written and oral formats**
- **Questioned about their interpretations by peers and forced to defend their results**

CONCLUSION

TSPSAs are a viable strategy to teach the study of Earth materials within the context of a broad-based undergraduate Earth Science degree program. This approach engages students in the learning process and has enabled me to move from a passive-recall teaching method to a more active-learning environment. Further, TSPSAs promote the larger objective of students conducting independent research projects, and I am pleased to see an increase in the number of students who are getting involved in these types of activities.

ACKNOWLEDGEMENTS

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