Transforming An Upper-Year Mineral Deposits Class Through Interactive Engagement

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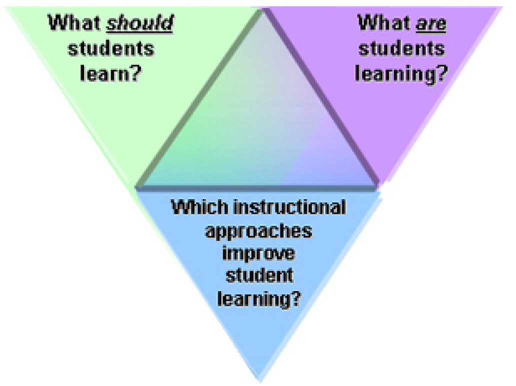
Introduction

EOSC 331 Introduction to Mineral Deposits provides an introduction to ore deposit geology and models related to mineral exploration. Study includes typical deposit types and their plate tectonic setting. There are typically 40-50 students in each Fall semester. The course is taught by two instructors (KH and JS) who split the teaching between them with about 1/3 team-teaching . Each week of the course, there are 2 one-hour lectures and one 3-hour lab. The course was officially optimized over two years (2009-2012) as part of the 7 year CWSEI (Carl Wieman Science Education Initiative) and unofficially since then. The resources supplied to the instructors as part of the official transformation were: the services of an STLF (Science Teaching and Learning Fellow, in this case BG) and a flexible "buyout". The buyout was used in the first year to recuse one of the professors from 0.5 of a course and in the second year for a graduate student to organize the labs and labs samples. KH, JS, and BG worked together on the course for the two official years. KH and JS have continued the work for the last two years.



The basic principles of the CWSEI

Goals

We rewrote course level goals and created lecture and lab level goals.

Existing course level goals were redrafted using standardized and simplified language. Course goals are for the students as much as they are for the professors, so clarity is an important factor. The course level goals are:

The overall goal of the course is to provide students with a basic scientific framework for understanding the origin and distribution of mineral deposits on planet Earth.

By the end of the course students should be able to:

1. Use basic hand-specimen description of rocks to identify the mineralogical, chemical, structural and paragenetic character of mineral deposits and their associated host rocks.
2. Describe the essential geological setting (mineralogical, geochemical, structural, tectonic, temporal) of the main mineral deposits types that provide the majority of the metals required by human society (e.g., Ti, V, Cr, Ni, PGE, Cu, Mo, Au, Ag, Pb, Zn, U, Fe).
3. Discuss the key geological processes responsible for mineral deposit genesis.
4. Describe how these deposits are distributed throughout geologic time (Archean to Cenozoic) and in space (e.g., mid-ocean ridge, continental arc, back-arc basin).
5. Develop a conceptual **Source-Transport-Trap (STT)** model for understanding the genesis of mineral deposits on Earth and their relationship to plate tectonics in time and space.

Lecture level goals

In general there are between 5 and 7 goals for each lecture. These were developed mostly in the first year of the transformation, and have been iterated each year since. For example, from the lecture on Banded Iron Formation:

At the end of this lecture, you will be able to:

1. Describe the essential mineralogic and geologic characteristics of banded iron formation and high-grade iron ores.
2. Describe and explain how, why, when, and where iron formations formed taking into account secular changes in the oxygen and Fe^{2+} content of the oceans from the Archean to the Phanerozoic.
3. Explain how low-grade magnetite-rich iron ores (taconite) are upgraded by supergene/hypogene enrichment to martite-goethite and high-grade hematites ores.
4. Explain the origin of BIF and high-grade iron deposits within the framework of Source-Transport-Trap (and be able to compare them to other deposits using this framework).

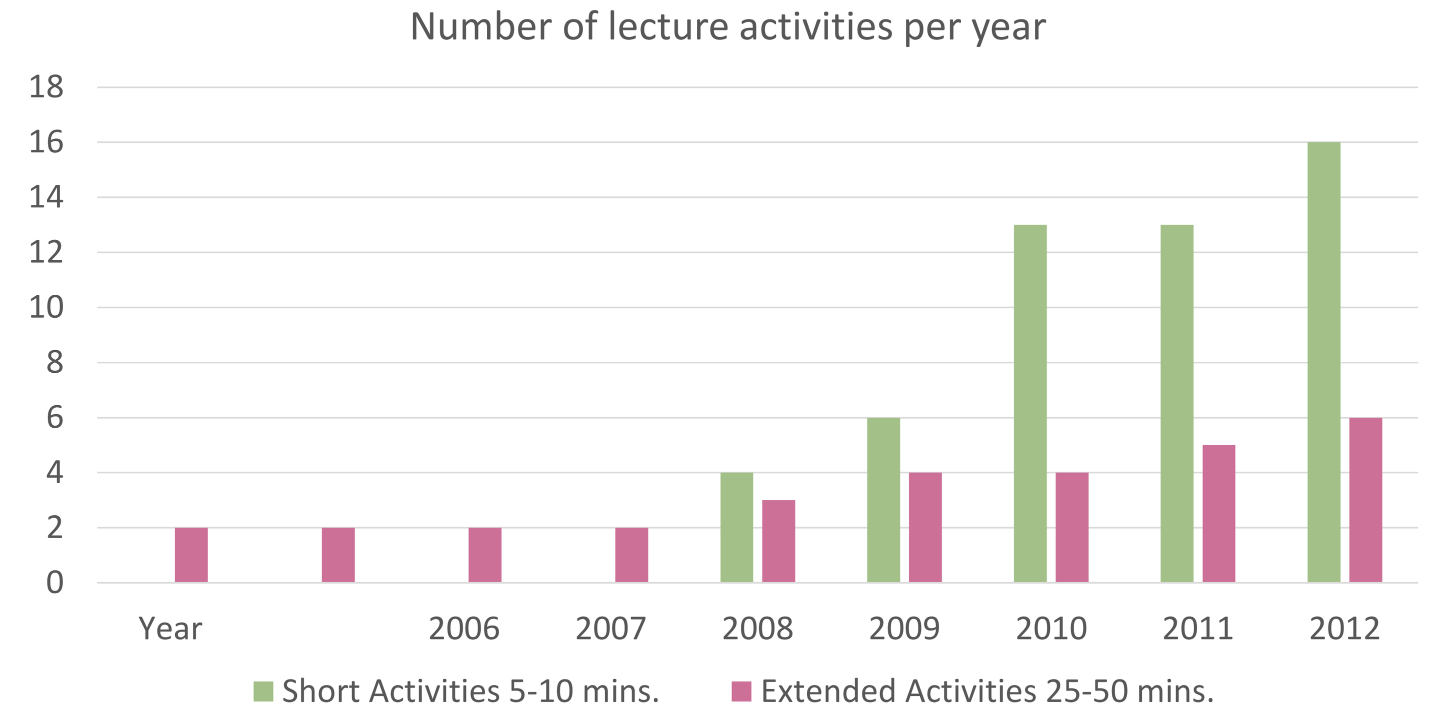
Frameworks

To help students learn course content is organized into three frameworks. These are:

1) Source/Transport/Trap (lecture)
2) Mineral deposits in space and time (lecture)
3) Deposit scale (lab)

Learning Activities

One of the main features of the course is a focus on active construction of knowledge during the lectures. This class now contains many activities that vary from 5 minutes to multiple classes in length. Such activities are difficult to develop, they take both skill and time. In some cases, instructors may spend up to 30 hours from idea to completion. Another difficulty is that some instructors may need to be convinced of the benefits of active learning. As experts, it is difficult to let go of our content and there is never enough time in class. In EOSC 331, the number of activities increased dramatically over the development of the course.



Example: Poster Project and Forum

Time: 1 hour in a lab session

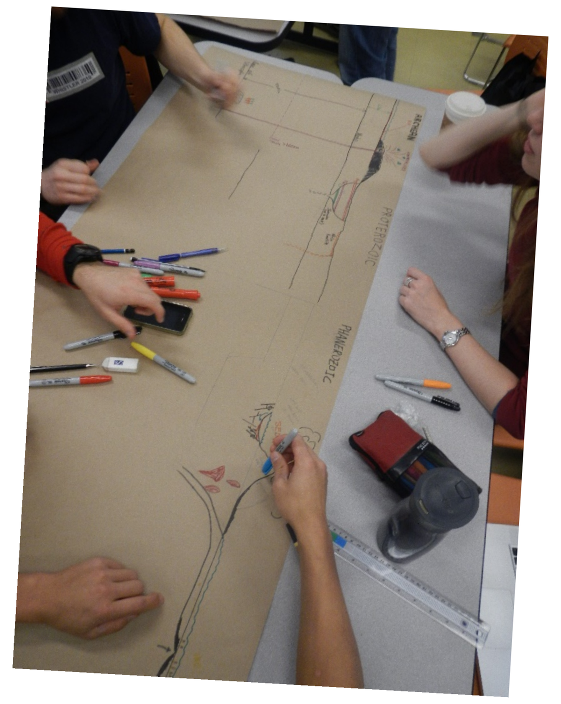
As a course project, students work in groups of 4 to research and develop a poster on a specific deposit. Project groups span the two lab sections, thus posters are presented in each lab section by two students. During the forum, one partner stands by the poster and explains it to interested parties. The other partner is required to visit 4-5 other posters, ask meaningful questions and record the answers as part of an assignment. Partners then switch and the second partner explains the poster while the first visits colleagues. The same happens in the second lab section and as a result each student stands by and presents their poster for about 30 minutes. Discussion is lively and questions are of high quality. A key component is that this activity is a forum and not a series of presentations to the whole class at once. A student self-assessment is completed at the end.

Example: Hydrothermal Concept Map

Time: 50 minutes

At the end of the series of hydrothermal deposit lectures, students are randomly given two hydrothermal deposit types. Students develop a complicated concept map as a synthesis activity. They use sticky notes to write down words and processes they think are important, and are then given a large sheet of craft paper and are told to arrange their notes into a logical framework that compares and contrasts their two deposits using the Source/Transport/Trap framework. The results are both impressive and colourful.

Example: Cross section Synthesis



Time: two 50 minute classes

The final activity is one that existed in a basic form in 2009 prior to the transformation of the course. Students get into groups of 4, are given markers and a very long sheet of craft paper, and are told to create a cross section that incorporates most of the deposit types discussed in class. Their cross section must include relationships to plate tectonics and lithospheric thickness, the relative size of each deposit, and also geologic time. This synthesis activity covers all three of the major course frameworks. The task is very challenging, but also very fruitful. Students work on the task for a full class, then in the next class the cross sections are posted for all to see and the whole class discusses how they could be improved.

Acknowledgments

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Labs

Labs in EOSC 331 consist of rock suites, intense observations of samples, and questions about the genesis and arrangement of deposit types. Labs focus more on the framework of "Deposit Scale"

Lab redevelopment greatly changed the ways the lab functioned. Prior to transformation, labs were similar, but were handed in at the start of the next week. Many students would pick up the assignment then leave, coming in to look later in the week or just copying from friends. Labs are now handed in at the end of lab, making the lab a frenzy of activity. This focus on labs that must be completed in class was difficult to balance, labs were initially too long and took far too much TA time to mark. As is often the case, surveys also indicated that students were frustrated by the first iteration of the labs; only 18 out or 34 agreed with the statement "the lab format is useful to my learning." However by the second iteration of the new labs 32 of 37 students agreed or strongly agreed with the same statement. Similarly, the extremely hard lab exam is highly regarded. The following statements are common sentiments heard in the 3rd year field course later that year:

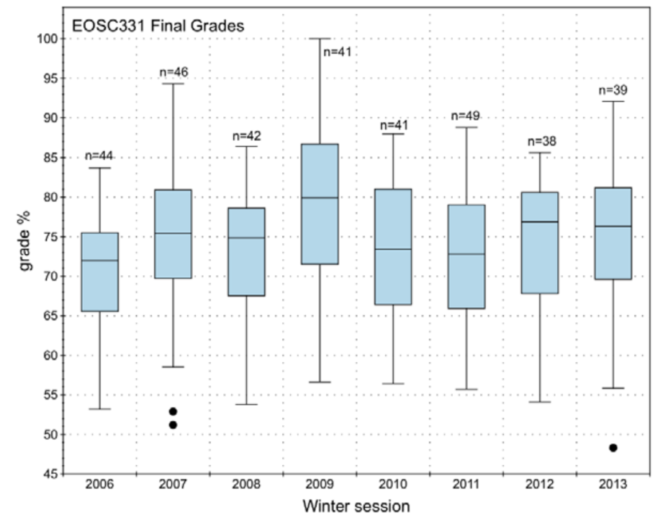
"the most intense exam in my undergraduate career so far, but worth it"
"studying with the suites of rocks from all 10 labs is a satisfying experience, because we actually know how to identify and describe all these rocks and minerals"

Metrics

Evaluating the effectiveness of educational change is difficult, especially if you are unable to get a pre-measurement of the course prior to development. We used a variety of metrics to evaluate the class over the years.

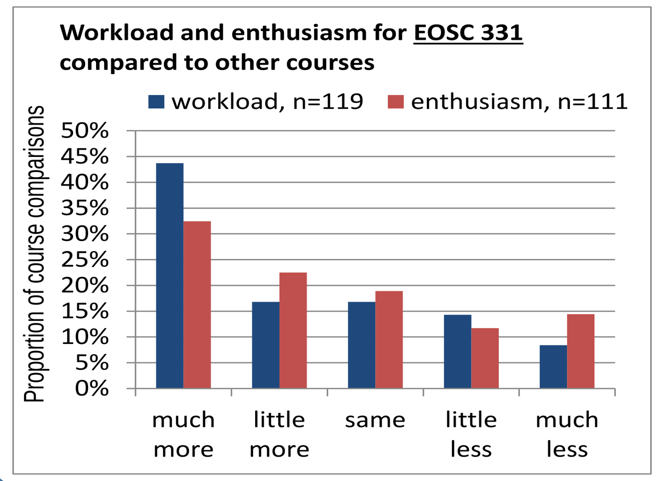
Final Grades

Assessment in the course consist of a Midterm Exam (10%), Lab Exercises (20%), Lab Exams (15%), Synthesis Activities (5%), Poster Project (15%) and the Final Exam (35%). Final grades show no change over time, however no change was expected. Though most assessments have changed, marking and grading procedures, policies, and philosophies are similar.



Instructor Attitudes

Instructors – Pre- and post_transformation interviews were completed with both instructors prior to and after development of the course. Future work will focus on changes attitudes between interviews (a 2 or 3 year gap).



Student Workloads vs Enthusiasm

As part of a department wide survey of each class in Earth Ocean and Atmospheric Science, Students were asked to compare the amount of work in this course against the amount of work in other courses they were currently taking. This survey was done in each class at the end of the September 2013 and January 2014 semesters (see Jones *et al.* for more information). For this class, students report a much higher workload than other courses, however they also report higher enthusiasm. When compared to (30) other classes in the department, EOSC 331 has one of the most favourable results for this metric, exactly what we would hope to observe.

Conclusions

- It's not necessarily about increasing grades
- It is possible to increase student workload and also increase enthusiasm
- Instructor workload while developing new expertise and redeveloping the class simultaneously can be extremely high. Compensation and consideration of this fact is very important
- Student and instructor satisfaction is very high
- It's never done (it's never finished)
- We have learned to love the "Chaos"

Select References

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* National Academy Press

Francis Jones, Sara Harris, & Brett Gilley (2014) *Comparing Student, Instructor and Observer Data to Assess a 7-Year Department-wide Education Initiative* International Improving University Teaching conference, Vancouver BC (July 2014)