Fueling Learning Outside the Classroom with Strategic Searching of the Geoscience Literature

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Abstract

For undergraduate geoscientists, significant learning outside of the classroom is fuelled by the exploration of the geoscience literature to gather information for papers and projects. Faculty are often disappointed by the findings of their students or are concerned about the amount of hand-holding they must do. To help improve students' out-of class literature exploration, a partnership was created between a geoscience faculty member and a science librarian to teach students about finding relevant geoscience literature, and the usefulness of different types of sources.

In two sequential sophomore level geology classes (Mineralogy and Petrology) students were assigned term papers. The science librarian provided two hours of library research instruction in each class. In Mineralogy, library instruction topics included an overview of the types of geological literature, sources for mineralogical information, and basic GeoRef searching. In Petrology, the library research session covered advanced searching techniques in GeoRef, introduced citation tracking using Scopus and Google Scholar, and introduced additional sources for geologic information.

The impact of using a thoughtful approach to literature research was evaluated through questionnaires, an analysis of student bibliographies, and student reports of their search strategies. Questionnaire results indicated that after completing Petrology, students had an increased awareness of particular resources (GeoRef, Scopus, subject encyclopedias, Google Scholar, etc.), used a wider variety of search strategies and had a more complete knowledge of the usefulness of various resources. Analysis of student bibliographies from Mineralogy and Petrology papers revealed an increase in the inter-connectedness of references cited, an increase in the percentage of scholarly references and a wider variety of resource types. Improved research skills have also been noted by faculty in other upper level geology courses.

The geological literature fuels learning outside the classroom. Teaching students to use a strategic literature search process that is bigger than GeoRef or Google equips them with the skills to discover and explore the work of other geoscientists.

"the sessions with the science librarian allowed us students to find the articles using the shortest route. we didnt have to look all over the school website and waste time. she helped us refine our search."

Motivation for Collaboration

For many geoscience faculty members, there is a general dissatisfaction with students' abilities to search for, find, and appropriately use geoscience information. To address this, we designed instructional materials to help students improve their research skills and learn beyond the classroom.

The Old Model Pre-Collaboration Research Guidance at Geneseo:

- Students were assigned a paper and encouraged to use geological search engines such as GeoRef to discover resources for their writing. There was limited in-class instruction regarding research strategies.
- Students were verbally discouraged from using Google and Wikipedia.
- Student bibliographies included citations to websites, meeting abstracts and Wikipedia.
- Students perceived meeting abstracts as counting towards their "scholarly article" paper requirements.
- Significant office-hour time was spent working individually with students needing research help. Common questions include:
  - Why can't an abstract count as a scholarly source?
  - Where is the rest of the paper associated with a meeting abstract?
  - Why can't I cite Wikipedia?
  - What source should I be using to find scholarly information?
  - I can't find anything on my topic!

The New Model Collaborative Research Guidance at Geneseo:

- Students are assigned a paper and encouraged to use geological search engines such as GeoRef to discover resources for their writing.
- Class time in the first two upper-level geology courses is dedicated to the teaching and learning of research strategies. The instruction is done collaboratively between a geology faculty member (Farthing) and SUNY Geneseo's science librarian (Swoger).

The primary goal was to improve student research skills by teaching them about the resources available, the types of information sources they were likely to find, and the best ways to obtain their needed information.

The outcomes of this collaboration were assessed throughout the 2009-2010 academic year.

Why does library-based research help students learn beyond the classroom?

- We are helping to equip students to delve into the geological literature.
- The geological literature is rich with ideas and concepts that we may not cover in our classes.
- Exploring through the literature is akin to a "fieldtrip for the brain", where students can explore other geologists' experimental setups, field setting descriptions, models for Earth processes, etc.

Research Methods in Mineralogy

What types of information are available?

Mineralogy is the first upper level course students take after completing Physical and Historical Geology. It is one of the first courses in which students start to learn about the culture of the geoscience discipline, and it often contains a student's first exposure to field work. Formally introducing them to the geoscience literature supplements and supports what they learn in the classroom and in the field.

In the Fall 2009 semester, students were asked to write a 5-10 page paper about a mineral of their choice. For most of these students, this was the first geology term paper they had ever written. They were asked to include standard information about their mineral (provenance and history, chemistry and structure, mineralogical importance) from reliable sources. At least 3 of their sources had to be from the scholarly literature.

Science librarian Bonnie Swoger visited the class on two occasions to provide hands-on instruction. Students brought laptop computers into the classroom (either their own or borrowed from the library) to allow for active learning during the sessions.

Session 1: Introduction to the geological literature and sources for mineralogical data.
In order for students to effectively search the geoscience literature, they must understand the types of materials they may find and their uses.

Students were introduced to a subset of the types of geological literature through a pre-session assignment (see figure 1). This assignment fueled in class discussions during the first 1-hour library session where we expanded the list of literature types and discussed how each resource might be useful (see table 1). During this session we also used a jigsaw activity to introduce students to thematic books and websites that would be helpful to their project.

Important discussion points:

- We introduced the concept of peer review and commented on the use and value of peer review in the geological literature.
- We acknowledged that sources like Wikipedia can be useful in many ways, but do not represent the scholarly geoscience literature.
- We discussed the limitations and value of conference abstracts. This is important because the primary search tool for the geoscience literature (GeoRef) contains thousands of abstracts from professional conferences. Students often assume there is a published paper associated with these abstracts and often request them through ILL in hopes of getting the complete paper.

After this discussion about the geoscience literature, the jigsaw exercise introduced several sources for mineralogical information, both online and in print:

- Mindat.org
- Webmineral.com
- *Dana's New Mineralogy* (7th Edition, 1997)
- Additional print materials were mentioned in class and included in the online resource guide for the class.

Table 1: Types of geological literature discussed in class and appropriate use in scholarly research

Types of Literature	Possible Uses for Research
Journal articles	• Formal communication between geologists. • Source for original data, research and discoveries • Counts toward "scholarly sources"
Technical reports (e.g. USGS reports)	• Source for original data, research and discoveries • Most count toward "scholarly sources"
Geology news articles (e.g. Geotimes)	• Useful for selecting topics • Providing background information • Tracking down references cited
Books (reference materials)	• Basic factual information, • Providing background information • Tracking down cited references
Books (Monographs and Special Papers)	• Often a source for original data, research and discoveries • Most count toward "scholarly sources"
Conference Abstracts	• Identifying researchers in the field • Identifying keywords
Geology websites (reliable sources such as Mindat.org)	• Basic factual information, • Background information, • Tracking down cited references
Other websites (questionable reliability, including Wikipedia)	• Identifying keywords, • Finding a topic idea, • Tracking down cited references (if scholarly)

Session 2: Searching the geoscience literature: finding books, articles, and developing a search strategy
Several weeks later, once the students have had an opportunity to find some mineralogical information and finalize their term paper topics, the science librarian returned for a second one hour session.

In this session, we introduce GeoRef in detail as the primary tool for finding scholarly geoscience information.

Because students were already familiar with the types of resources found in GeoRef, class time was spent reviewing some basic mechanics of the database, teaching students to access full text articles online (and in print), and teaching students about Interlibrary Loan (a vital, heavily used resource at a small college like SUNY Geneseo).

Students had an opportunity to practice searching for information on their chosen mineral while the professor and librarian were available to offer aid and insight. An in-class exercise walked students through the process of brainstorming appropriate search terms, using resources to find additional relevant search terms, and conducting the search in GeoRef.

Research Methods in Petrology

Beyond keyword searching

For this class, the assignment was specifically designed to build on the research skills students gained in the library instruction sessions in Mineralogy. Students were asked to write a term paper about the igneous or metamorphic petrology of a particular area, chosen in coordination with a department sponsored field excursion during the January term. Spring 2010 explored the geology of the Death Valley region.

Two collaborative sessions were included in this class.

Session 1: Geographic terminology and finding a topic
Effective searching of the geological literature requires knowledge of a topic and the corresponding terms. Instruction time was spent examining how terms may vary for a geologic or geographic feature (e.g., pluton, magma chamber, intrusion, batholith, etc.).

The paper topic for Petrology was very open ended, so students were given guidance and time in class to apply three strategies for finding a topic:

1. Searching GeoRef with broad terminology, then narrowing the topic by finding appropriate keywords from relevant citations.
2. Exploring books on the geology of the region. The *Roadside Geology* and *Geology Underfoot* series were especially helpful for finding topics associated with the Death Valley region.
3. Exploring websites. State geological surveys had a lot to offer, as did the USGS website and other reliable sources.

Session 2: Advanced search techniques in GeoRef, plus citation searching in Scopus and Google Scholar
In the second collaborative library session, held two weeks after the first, the science librarian introduced advanced search techniques and additional databases (see table 2).

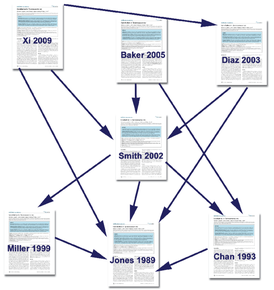

Figure 2: Diagram of the citation chain. Both Scopus and Google Scholar provide an easy way for students to explore these connections.

Table 2: Search tools taught in Petrology

Search Tool	When and Why to Use it	Skills taught
GeoRef	• Largest breadth and depth of geoscience literature • Includes citations to the literature from 1785 to the present	• Limiting results by document type • Author searching • Using database keywords and subjects • Expansion of the search based on additional terminology
Scopus™ (Elsevier) refine your research SCOPUS	• Includes citations and cited references for the scientific literature from 1996 to the present. Similar to Web of Science (Science Citation Index)	• Same search techniques as GeoRef • Citation tracking through time (see figure 2). Although citation tracking is a common search technique used by researchers, our assessment data indicate that early career undergraduates have not yet discovered this technique.
Google Scholar Google scholar beta	• Full text search capability for the documents it indexes • Useful for topics like specific rock formations or locations • Citations and cited references for many items • Familiar Interface	• Same search techniques as GeoRef and Scopus • Finding the full text of articles referred to online

"I came back to my computer and checked out the Wikipedia page for glauconite, and realized that it is being researched as a potential fertilizer and as a pigment in paints. In GeoRef, I typed in the keywords "glauconite" and fertilizer" and pulled up some information."

Geoscience Literature Assignment

Locate and examine the articles below, then answer the questions below.

Article 1:
Gramling, C., 2008, Are we Square?: Geotimes, v. 53, p. 18.

Article 2:
Belonoshko, A.B., Skorodumova, N.V., Rosengren, A. and Johansson, B., 2008, Elastic Anisotropy of Earth's Inner Core: Science, v. 319, p. 797-800.

Article 3:
Van Gosen, B.S., Lowers, H.A., Bush, A.L., Meeker, G.P. Plumlee, G.S., Brownfield, I.K. and Sutley, S.J., 2002, Reconnaissance Study of the Geology of U.S. Vermiculite Deposits - Are Asbestos Minerals Common Constituents?: U.S. Geological Survey Bulletin 2192, 8p.

On a separate piece of paper, answer the questions below for each of the articles you examined.

Bring your answer sheet to class.

1. Where are the authors of each paper employed? What do you think is their job (give your best educated guess)?
2. Briefly describe how each article is organized.
3. Look carefully – how does the author describe the goals or purpose of the article (this can often be in the abstract or introduction).
4. How might a geologist use each of these articles? Try to list two possible uses for each article.
5. How do the authors refer to the work of other geologists within each article?

Figure 1: Pre-session homework assignment given to students before the first library session in mineralogy. Students brought their answers with them to class, leading to a more productive in-class discussion about the geological literature.

"I realized finding research is difficult because sometimes the answers and articles I want aren't right in front of me. Sometimes I would have to vary my search terms, or look up similar topics related to my own in order to find valuable information."

Assessment

Overall, students found most of the content in the library sessions to be useful. While a few students indicated that they were already aware of everything covered in the library sessions, most students found the sessions helpful for pointing out relevant resources (topical books or websites) and improving their research techniques.

The effectiveness of the collaboration was assessed through both semesters using multiple methods:

- Students submitted a statement of their research strategies when turning in their final papers
- Students answered an end of class survey testing student learning and asking about student attitudes and behaviors
- Student bibliographies were analyzed in both semesters to see what types of resources they were using and to try to determine if students were using the citation tracking techniques we taught them.
- 16 students completed assignments and assessment surveys for both classes, allowing us to chart student progress.

Understanding and use of non-scholarly materials (including conference abstracts)

One of our primary goals was to help students understand what scholarly material is, and how they could use the non-scholarly material they find in appropriate ways.

From the fall to spring semesters we saw an increase in the percentage of scholarly sources used (from 70% to 83%), and a decrease in the number of websites cited (from 2.4 websites per paper in the fall to 0.7 websites per paper in the spring).

Critically, 75% of students (12/16) could successfully identify a conference abstract from a GeoRef citation after the fall semester. This increased to 100% (16/16) in the spring semester.

In both end of semester surveys, students were asked how a conference abstract could be useful to their research (see table 3). After the fall semester, many students were able to indicate that an abstract could help lead them to other sources, but additional experience during the spring semester allowed them to be more specific about how this might happen (including identifying relevant authors or providing useful search terms).

Table 3: Coded student responses to the question "How can a conference abstract, like those from the Geological Society of America Annual Conference, be useful to you?

How can an abstract be useful to you?		Response
Fall 2009	Spring 2010	
5	1	Lead to other sources (in general)
4	9	Identify relevant authors
2	4	Provide useful keywords
5	1	Lead to the actual article (not understanding what a conference abstract is)
0	1	Topic Ideas
0	1	Not Useful
3	1	Information about the conference
4	2	Background Information
0	1	Current Research

Student search techniques

The library sessions presented two primary search techniques that could be evaluated with student research statements and bibliographies: keyword searching (familiar to most students) and citation tracking (new to most). Student research statements indicate some use of advanced keyword searching techniques (use of AND, OR, NOT and the use of truncation symbols like *).

Citation tracking was mentioned directly by 46% of students in their research statements. We also examined student bibliographies for evidence of student use of citation tracking. A student who successfully used this technique would turn in a list of sources that were interrelated. By examining the references for each item in a student bibliography, we calculated a *connection ratio* (number of cited by connections divided by the number of references). Connection ratios range from 0 (none of the items in the bibliography cite each other) to 1.63 (a highly connected bibliography). For the purposes of this assessment, we estimated that ratios larger than 0.5 indicated that students were utilizing the citation tracking technique. For the fall semester (prior to teaching the technique), only one student had a connection ratio of 0.5. In the spring semester, 75% of students had connection ratios larger than 0.5. This appears to be a new metric, and will need more analysis to determine it's value and usefulness.

Use of resources presented in class

Drawing from entries in student bibliographies and student summaries of their research strategies, we know that the majority of students used the resources presented to them in class.

In Mineralogy, we introduced many resources and search tools, and students reported that they were using them. From student bibliographies, 88% of students (n=17) used one of the three sources for mineralogical information we presented, and 65% of them used the print resource Dana's Mineralogy. Based on student research statements, 72% of students in Mineralogy used GeoRef to find articles (n=11), and this increased to 100% of students in Petrology (n=13).

Additional resources discussed in class were also used in both Mineralogy (Worldcat Local, 55%, Google Books, 27%) and Petrology (Scopus, 54%, Google Scholar, 62%)

Student attitudes

While we have evidence that students learned from this instruction, we also have evidence that they found the instruction useful. At the end of the fall semester (mineralogy) students were asked if they found the library sessions useful in helping them find books and articles. Most students found the sessions useful with an average response of 3.8 out of 5 (Figure 3).

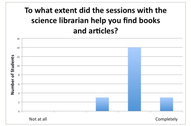

Figure 3: Distribution of student responses on the end of semester survey in Mineralogy

Beyond Mineralogy and Petrology - did the learning stick?

Anecdotal evidence suggests that faculty teaching upper level geology classes at SUNY Geneseo have noticed an improvement in student research skills. This improvement was noted in the department assessment of research skills conducted in 2010 as a part of general education assessment at the college.

Incorporating this in your classes:

If you are able to team up with a librarian at your institution:

- Work with the librarian to make sure that appropriate geological resources are easily found through the library website.
  - Show these resources to your students in class.
- Invite the librarian to collaborate on research assignments and in class instruction.
- Nurture the relationship between your students and the librarian. This provides greater opportunities for students to seek help finding resources and citing sources outside of the classroom and faculty office hours.

If you can't team up with a librarian at your institution:

- Link to appropriate resources from your course management system.
- Put appropriate books on reserve to help students select a topic.
- Dedicate an hour of class time to geoscience literature research skills.
  - Teach students about the types and uses of the geoscience literature.
  - Demonstrate and let students practice using databases for finding the literature.
  - Troubleshoot student strategies.
- Create partnerships between experienced students and early career students to share these skills.

General recommendations:

- Accept that students will use Google and Wikipedia (despite exhortations to the contrary).
  - Teach them how these sources are different from scholarly geoscience sources.
  - Teach them how these sources can be used in a responsible way (topic ideas, keywords for searching, utilizing the scholarly sources they cite, etc.).
- Ask students to write down brief descriptions of their search strategies to help you evaluate their skills.

Changes and future plans

The importance of understanding the role of the conference abstract in geology has led to changes in the assignment given in the fall semester course (Mineralogy). Following a brief discussion about geology conferences and conference abstracts led by the faculty member, students were asked to locate a conference abstract that highlights the use of a mineral in research. The term paper should use the conference abstract as a starting point, present a brief overview of the research (e.g., techniques used, questions asked, the value of the research) and the role that the mineral played in the research. The paper is also required to include basic information about the mineral that was discussed in the abstract.

This change provided a more focused approach for finding scholarly research about minerals. In the library sessions, students were taught to do author searches in GeoRef, and how to find appropriate keywords from their original abstract. We were also able to briefly introduce the concept of citation searching in the fall Mineralogy class, although this will be emphasized in the Petrology class in the Spring.

We believe that this approach will help reinforce the concept of what a conference abstract is and how it can be used in the research process.

Overall, both the librarian and faculty member have learned a lot through this collaboration. The librarian was able introduce techniques and research resources not familiar to the faculty member, and the librarian was able to learn quite a lot about student behavior in the classroom setting.

"I've learned how to use other sources like articles (not just journals) and abstracts as references. I've learned how to research scientifically, rather than for my education or spanish classes."