1. **State your rationale or question for this assessment activity:**

Undergraduate research is thought to be an effective way to improve students’ critical thinking skills. However, both college-wide and in Geoscience and Biology Departmental assessments, we see that students’ final research papers rarely reach the “capstone” level.

In particular, our graduating seniors should be better at:

- Explaining the issues or the problem to be solved
- Evidence (particularly questioning the viewpoints of experts and recognizing when sources have reached contradictory conclusions)
- Analysis of their own assumptions and the assumptions behind their methods
- Discussion of their positions (or interpretations of their data) in the context of previous studies
- Using evidence to support their conclusions

We see these problems in the research proposals that students write, in background literature reviews, and final research theses. The literature on the effectiveness of undergraduate research has found two, possibly conflicting, approaches to be especially effective for students:

- **Ownership:** students get more out of research experiences when they have a sense of ownership - when they have defined their own question, or made their own choices about what approaches to take to solve the problem.
- **Authenticity:** “authentic” research is typically described as something that solves a real, important problem in a discipline. Typically the most “authentic” research is connected to the
larger research question of a faculty member; students have a sense that they are solving one piece of a bigger puzzle.

These two approaches can be at odds with one another. If a faculty member’s research agenda defines the problem, how does a student develop a sense of ownership in it? If the student defines the question, how can the faculty member’s expertise and greater experience with the important problems in the discipline be used effectively - especially if the student is curious about a problem that the faculty member has little experience with?

The Geoscience Department’s past approach has been to allow students to develop their own research questions during GEOL 381 (Research Methods), and then to work with any of the faculty in the department on the problem throughout a two-semester Senior Seminar sequence (GEOL 496/497). In this model, students worked on their critical thinking skills in problems that were not tied to their own research questions, while simultaneously developing proposals for research. Starting in Spring 2016, we have moved to a two-semester model (GEOL 381/GEOL 496), in which a cohort of students works with the same faculty member. As we change models, we are struggling with two questions:

1) What is the best balance between ownership and authenticity in student research projects?
2) Can students develop critical thinking skills while working on their own research (collaboratively with a faculty member), and is this approach as effective (or more effective) than developing those skills in stand-alone exercises?

This approach is similar to the one adopted by the Biology Department several years ago. Geosciences will be fully implementing this change for the first time in Fall Semester 2016 (GEOL 381 with Dr. Harvey); students taking GEOL 496 (with Dr. Hannula) during Fall 2016 will experience a hybrid of the old model and the newer model. In addition, we wish to compare critical thinking skills of students during the process of proposal writing (Drs. Fenster and Harvey) vs. completion of final theses (Drs. Dott and Hannula) in Fall 2016. Therefore, we propose a team of faculty from both Geosciences and Biology to investigate the roles of ownership vs authenticity and of stand-alone critical thinking exercises vs critical thinking practice embedded in research projects.

2. Describe the instructional modifications and how critical thinking and problem solving were improved through these modifications. (Please give as much detail as possible):

As described above, the Geosciences department has shifted to a new senior thesis model wherein a single faculty member leads the students through the two-semester sequence. This model mimics that employed by the Biology department. The equivalent courses in each department (and instructors for fall 2016) are listed in the table below.
<table>
<thead>
<tr>
<th></th>
<th>Geosciences</th>
<th>Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st course in sequence</strong></td>
<td>GEOL 381 (Harvey)</td>
<td>BIO 496 (Fenster)</td>
</tr>
<tr>
<td><strong>2nd course in sequence</strong></td>
<td>GEOL 496 (Hannula)</td>
<td>BIO 497 (Dott)</td>
</tr>
</tbody>
</table>

During the first course in each sequence (GEOL 381 and BIO 496), students work with a faculty member to develop a research question and write a research proposal in collaboration with that faculty member. The signature assignment in each of these courses is a formal research proposal. Within these proposals, students should

1) Explain their problem or research question clearly
2) Use published work to build a foundation for proposing a way to test their hypotheses
3) Show how their proposed work can address the problem

During the second course in each sequence (GEOL 496 and BIO 497), the signature assignment is the final thesis paper. Within these papers, students should:

1) Explain the issue or problem addressed in the paper.
2) Discuss previous research relevant to understanding the problem.
3) Either analyze previous work (i.e. Geosciences and Biology literature reviews) or use original data to draw a conclusion addressing the issue or problem at hand.
4) Discuss the assumptions behind and implications of the conclusions.

The second courses (GEOL 496 and BIO 497) provide an opportunity to compare senior thesis models in which the research questions were entirely student-driven (GEOL 496; none of the students worked on Dr. Hannula’s research problems) with senior theses in which the same faculty member helped students develop their questions and supervised the research (BIO 497, Dr. Dott). The GEOL 496 students had completed critical thinking exercises as part of their prerequisite GEOL 381 (taught by Dr. Ray Kenny, spring 2016). If a combination of student ownership and stand-alone critical-thinking exercises is the most effective way to develop student thinking, then the Geosciences projects should reach capstone levels. If it is more important to use faculty expertise to develop strong research questions, the Biology projects should reach capstone levels.

3. **Please describe how you reviewed and distributed results (how, when and to whom):**

Signature assignments from the first course in the sequence (GEOL 381/BIO 496) were assessed by faculty teaching the second course in the sequence (Drs. Hannula and Dott). In this assessment, the
research proposals from fall 2016 (from the 11 students in GEO 381 and 9 in BIO 496) were evaluated for “Identify a Topic,” “Incorporate Information and Existing Research,” and “Select or Develop a Design Process” using the Colorado Commission on Higher Education Inquiry and Analysis rubric.

Signature assignments from the second course in the sequence (GEOL 496/BIO 497) were assessed by faculty teaching the first course in the sequence (Drs. Harvey and Fenster). The thesis papers were evaluated for “Identify a Topic,” “Incorporate Information and Existing Research,” “Select or Develop a Design Process,” “Analyze and Interpret Evidence,” and “Draw Conclusions” using the Colorado Commission on Higher Education Inquiry and Analysis rubric. Because there were 17 students enrolled in GEOL 496, only 9 papers were scored, to provide similar-sized data sets from each course.

Results of the assessment are being shared with our respective departments, especially with those faculty taking on the next round of senior thesis students (GEO s17 = Dr. Gianniny, BIO s17 = Drs. Korb, Lehmer, and Ortega). We anticipate that brainstorming will continue based on these results and as additional rounds of senior thesis students complete the course sequence in coming semesters.

4. **What did you learn from this activity?**

Summary of rubric scores from both departments:

<table>
<thead>
<tr>
<th></th>
<th># scored</th>
<th>Identify a topic</th>
<th>Incorporate information and existing research</th>
<th>Select or develop a design process</th>
<th>Analyze and interpret evidence</th>
<th>Draw conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO Proposals (BIO 496)</td>
<td>9</td>
<td>2.89</td>
<td>2.78</td>
<td>2.72</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BIO Theses (BIO 497)</td>
<td>9</td>
<td>2.44</td>
<td>2.44</td>
<td>2.44</td>
<td>2.67</td>
<td>2.44</td>
</tr>
<tr>
<td>GEO Proposals (GEO 381)</td>
<td>9</td>
<td>2.59</td>
<td>2.72</td>
<td>2.59</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>GEO Theses (GEO 496)</td>
<td>9</td>
<td>3.22</td>
<td>3.00</td>
<td>3.06</td>
<td>3.00</td>
<td>3.10</td>
</tr>
</tbody>
</table>

Results show that in Geosciences, students in the second course of the sequence show an improvement across all categories as compared with those in the first course of the sequence. This result suggests that the Geosciences previous senior thesis model (in which students work on many different faculty members’ projects, under the guidance of one faculty member), was successful in improving students’ abilities to describe problems, synthesize background information, and design strategies to solve the problem.

This improvement is not detectable in the scores from the Biology Department, which employs the new model wherein one faculty member provides the project ideas and all of the support along the way.

These results can be interpreted in many ways, some of which we discuss below:
Value of multiple faculty perspectives?

Upon seeing the results, we discussed the possibility that documented improvement in scores from GEO 381 to GEO 496 under the old model shows that when student work is repeatedly reviewed by both the research advisor and the instructor of GEOL 381/496, they end up doing a better job of explaining the problem, devising research strategies, presenting and analyzing results, and discussing the import of their conclusions. In other words, perhaps having a single faculty member advising and reviewing student work throughout the thesis is detrimental to the student due to the lack of diverse perspectives. Since that is the current model for both departments, perhaps that issue could be alleviated by having sessions during the semester in which students present their work to other faculty members to provide that feedback. In any case, this is an ongoing discussion among our departments as we shift into a model where one faculty member serves as primary advisor and course instructor throughout the sequence. It should be noted that Biology used to incorporate feedback from multiple faculty members before it was dropped due to time constraints.

Reviewer bias(es)?

Another question arising from the assessment results regards the robustness of the data. For example, does filtering out literature reviews in GEOL 496 from the assessment pool bias the results towards stronger students in the second course of the sequence? In the past literature reviews have been the preferred route for weaker students, yet they may not have decided on the literature review route until they are partway through the second course in the sequence. This could push the scores from the 2nd course higher than those from the first. The Biology program does not offer the literature review option to students.

Bias may also come from the reviewers themselves. As discussed above, Professors Fenster and Harvey reviewed the completed theses from Professors Dott and Hannula, respectively, and vice versa. Each reviewer may apply the rubric differently — any bias coming from the reviewer could manifest as starkly different numbers for each course. Similarly, this exercise revealed that it can be challenging for a reviewer to accurately judge the quality of theses written outside of that reviewer’s area of expertise. These challenges will be considered in future assessments of the capstone courses in our respective majors.

Student preconditions?

It was also discussed whether the success of students in the senior seminar/thesis program is closely tied to students’ academic abilities and preparation going into the program. Some reviewers felt that this is indeed the case, which would imply that the research/thesis experience does little to level the playing field with students with a wide range of ability. It may also mean that classes stacked with stronger students may score better overall, rendering the rubric score averages less meaningful.

5. How did it impact what you have done in the classroom?
To address the issue of student feedback coming from a single source, we are considering the value of having students receive feedback on their (draft) poster presentations from additional faculty members. Feedback at that stage could improve the quality of student theses and/or posters.

Dr. Harvey is addressing his cohort’s weakest-scoring category (Incorporate Information and Existing Research). The assessment made it clear that there is room for improvement in their ability to synthesize relevant information from a range of sources with different points of view into a coherent ‘background’ section of a thesis proposal. Discussion of this issue concluded that perhaps students need to be introduced to professional science writing earlier and more often than they currently are.

Dr. Fenster and Dr. Dott are also addressing the weakest-scoring category for the senior thesis (Incorporate Information and Existing Research) as this is a common problem observed in all the work evaluated for Biology. In addition to incorporating more instruction in scientific writing earlier in the Biology curriculum (i.e. introductory courses and 200-level course), a more thorough and comprehensive instruction in identifying and synthesizing relevant scientific literature would greatly improve this area of assessment. This might be accomplished by requiring assignments where students learn how to access and search scientific literature database websites.

Beyond these areas of possible improvement, both departments are constantly evaluating the strength of their senior thesis program and how it can be optimized to improve students’ critical thinking and communication skills. This assessment was a good start at what should be a multi-year study to track the effectiveness of the senior thesis model as it evolves and is refined in coming semesters. This is especially true for Geosciences, as they continue to transition into the new, 2-semester thesis model.

6. Any other additional information you would like us to know?

We discussed whether the FLC writing program provides appropriate advice to students in STEM fields, given that technical science writing takes a very different approach than the rhetoric-based approach employed by the COMP program. The instructors in that department may have little experience with formal science writing, and, anecdotally, may even have an unfairly low opinion of formal science writing). This disconnect might make it challenging for students to apply what they learn in COMP classes to their science writing. Outreach to the instructors in the writing program would be helpful to allow our students taking courses for their writing composition requirement to develop their skills in technical writing.

Please attach your signature assignment, scoring rubric and any other relevant information along with this form to labarrett@fortlewis.edu. If you have questions please contact, Lisa Barrett x 7615