

## ENVS 102L – FINAL REPORT

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### 1. Abstract:

The Environmental Science 102L course is designed to introduce students to global change and environmental concerns with a hands-on approach. The primary goals of the ENVS 102L redesign are to redesign the laboratory to help students more effectively learn the fundamentals of environmental sciences as well as to develop materials to help the instructors teach the content with research supported pedagogical techniques. We address the basic concepts of environmental science, which include the interdisciplinary aspects inherent within an Earth systems science field and the misconceptions associated with it. The developed content aligns with the NM Higher Education Department's competencies in Area III: Laboratory Science Competencies (UNM Core Area 3: Physical and Natural Sciences). To make these advances, we reassessed the student learning outcomes for ENVS 102L and redesigned 14 separate lab activities along with supporting materials: Student learning outcomes, background readings, pre-lab assessments, iClicker questions, post-lab assessments, assessment of outcomes, PowerPoint slides, activity keys, gradebook templates and other associated supplemental materials.

To quantify student success in the course, we embedded summative assessment questions into each lab activity. These were developed with adherence to our student learning outcomes. We collected assessment data using rubrics for nearly 600 students for each lab during the 2015-2016 academic year. Attitudinal data were also collected from the students as well as 15 different teaching assistants. Each successive review of the data (over 2 semesters) provided insights for planning student learning improvements. To improve student-success rates, we not only redesigned lab activities and supplemental materials, but also made pedagogical changes. Pedagogical changes included the development of teaching guidelines per each lab activity, lab training, and the development of a workshop regarding expectations of teaching assistants and the theories/science behind the pedagogy of active learning. We propose that these efforts will encourage our teaching assistants to better engage with the course materials and expectations. We also suggest that the course redesign is not only a way for to address student misperceptions of the subject matter, but to help Teaching Assistants learn to be more effective teachers. We have had positive results regarding the success rates of our students and positive feedback regarding the changes made in course design.

The development of lab redesign followed the methods supported by the STEM Gateway program and associated workshops. This includes the implementation of an enhanced active learning environment within our labs. This was made possible by incorporating iClicker questions with student discussion, pre- and post-lab assessments with guided reading, and small-group assignments. Using our knowledge of the *backwards-design* concept, the *ICAP model*, *SMART goals*, memory-forming processes, Bloom's Taxonomy, and other related concepts, we have made successful progress with the ENVS 102L course. As the course progresses, we intend to further modify the lab activities as needed so as to improve the learning experience for our students. This will, in turn, provide us with better outcomes.

## 2. Project motivation and goals:

Blue Planet Laboratory (ENVS 102L), along with the companion Blue Planet (ENVS 101) lecture course, is the introduction to the Environmental Sciences (ENVS) major. This laboratory can be used to excite students about science, introduce them to the field of environmental sciences, and to recruit students into our Environmental Sciences program. Notably, the ENVS majors include a larger number of Hispanic and Native American students than does the Earth and Planetary Sciences program and many of these students become interested in the degree while taking the Blue Planet courses. It was our motivation and goal to design or redesign laboratory activities to meet the NM Higher Education Department's competencies in Area III: Laboratory Science Competencies (UNM Core Area 3: Physical and Natural Sciences). It was our intent to align the laboratory activities to correspond with the needs and expectations of outcomes in preparation for students who will take this course as a gateway into the ENVS major, including increasing the quantitative rigor of the activities. We have designed the laboratory exercises to address typical misconceptions regarding the environmental sciences; these include misconceptions associated with climate change (e.g., how the greenhouse effect works), and energy and resource sustainability (e.g. oil future, environmental impact of demand on resources). We have also designed activities to help students understand the basics of practicing science, which include more authentic activities such as use of field equipment, having students collect field and laboratory data, and interpret their data and results.

Upon course completion, students will

- be able to construct a hypothesis, propose a test, and then complete the test using quantitative and spatial data.
- be able to make measurements and make calculations using those measurements that lead to graphical display and interpretation of data.
- be able to make and use observational data to infer geologic/environmental processes.
- be able to analyze graphical data and use the graphs to make interpretations.
- be able to effectively communicate (written and/or oral) an interpretation of quantitative and graphical data to evaluate a societally relevant environmental problem.
- learn the basics of functioning successfully in a field setting, including use of some basic equipment and techniques, and putting into practice the basic steps of collecting field data.
- be able to interpret scales and elevations on a topographic contour map.
- be able to use observational data in one context and apply this information in other contexts.

ENVS 102L is taught by graduate-student Teaching Assistants (TA), and these TAs change every semester. Therefore, one of our goals was to provide TAs with complete teaching guidelines along with keys and supplemental materials for each lab to help each TA to maximize their teaching effectiveness.

## 3. Project summary:

Each lab followed a particular template that we developed during our course redesign to maximize learning.

**Background Readings:** Readings along with guided questions were put together for each laboratory. These materials are hosted in UNM's learning management system, Blackboard Learn. Students are assigned background reading prior to each lab.

**Pre-Lab Assessments:** Assessments of 8 multiple-choice questions pertaining to the background reading were developed for each lab. Students were required to take the assessments prior to lab to hold them accountable for the readings as well as to assure preparation for the lab activities. The questions were randomly rotated in learn, such that each student had variations in their multiple assessments per attempt.

**iClicker questions:** Sets of iClicker questions were developed for each lab for use by the TAs. The goal was to have the TA ask a few questions, using peer instruction, to help guide the short 10-minute, content-driven, interactive opening lecture to make sure students understood the basics before proceeding to the lab activity. The content was based on the background reading and anticipated lab activity.

**Lab Activity:** Activities were designed or modified to meet the NM Higher Education Department's competencies in Area III: Laboratory Science Competencies (UNM Core Area 3: Physical and Natural Sciences). The laboratory activities were designed to correspond with the needs and expectations of outcomes in preparation for students who will take this course as a gateway into the ENVS major, including increasing the quantitative rigor of the activities, while acknowledging the absence of mathematics prerequisites.

**Post-Lab Assessments:** Assessments of 8 multiple-choice questions pertaining to each lab activity were developed for each lab. Students were required to take the assessments after the lab to hold them individually accountable for their understanding of the material. The questions were randomly rotated in Learn, such that each student received a unique assessment per attempt.

**Teaching Assistant Guidelines:** Guidelines were developed for each lab and includes general objectives, outcomes for the lab, suggestions for teaching the material, keys for the activity, organization of the lab and classroom management suggestions.

**Outcomes:** Outcomes-assessment questions were written for each lab, which corresponded to the student learning outcomes developed for each lab and the course. These questions were embedded in the laboratory worksheets. TAs are asked to collect outcomes data along with answering basic questions on how the lab worked. The outcomes data along with the feedback are used to improve continued efforts to improve the lab.

**LMS, Blackboard Learn and DropBox:** Each section of the lab has its own Learn site and we developed and provided all of the materials for these sites. Each site contains folders for each lab that include background readings, pre- and post-lab assessments, and gradebooks. TAs are given access to a DropBox folder that houses all of the files that students see in Learn along with TA guidelines, outcomes-assessment documents, and other supplements.

**Supplemental materials:** Supplemental materials such as pre-made PowerPoint slides with images for TA use and modification for their interactive presentations were provided. Also, documents with instructions on how to set up iClickers and use Blackboard Learn are available. Template gradebooks

are also provided for TA use as well as a general guideline for all TAs on the basics of teaching introductory labs.

#### 4. Assessment:

Both quantitative and qualitative data was collected from nearly 600 students during the 2015-2016 academic year. Outcome data were compiled from 27 course sections taught by 11 different Teaching Assistants. These assessments were divided into two sections: 1) a summative assessment question with an answer key and grading rubric, and 2) questions for each Teaching Assistant regarding the outcome question as well as supplemental lab questions to help us improve the laboratories for the future. These supplemental lab questions were created to give the Teaching Assistants a platform to state what needed to be fixed regarding the summative question and any other errors associated with the lab content/design/pedagogy. One of the changes that we made to our course curriculum as a result of assessing outcomes during fall of 2015 was designing a lab to meet our fourth outcome, "Students will be able to analyze graphical data and use the graphs to make interpretations." Although graphs, tables, and charts are used throughout the semester, we did not realize until the end of the semester that we did not assess this outcome with any of the labs. In our spring 2016 curriculum, we redesigned a lab activity that assesses this outcome.

The curriculum was improved in several ways. Each lab activity is unique in that improvements were made by implementing one or several of the following: Redesigning or creating entire labs, rewording questions, rewriting or changing the summative question that is used for outcome assessments, or changing teaching methods/pedagogical approach. Some lab assessment results showed significant improvements in student learning. One of our course outcomes is "Students will be able to construct a hypothesis, propose a test, and then complete the test using quantitative and spatial data". Our approach in teaching and assessing our students was implementation of a Scientific Method lab. In the spring of 2015, our combined exemplary and satisfactory outcome was 69%. With some modifications during the redesign project, 87% of the students in the fall 2015 sections received a satisfactory or exemplary grade based on our outcome question. Upon further review, we decided that the best way to convey to students what and how a hypothesis is conceived was to split up our prior outcome question into multiple parts. This allowed students to compartmentalize and foresee what was expected of them. With slight changes in the lab we were able to improve the satisfactory or above score to 99% by spring 2016. Because of the results of the Scientific Method lab, most of our assessments are multiple questions or multiple parts of a question. We've designed the rubrics to categorize how well students understand the materials. The categories are exemplary, satisfactory and unsatisfactory. Our results show that all eight of our outcomes are well above 70% of satisfactory or above with many showing improvements from one semester to the next. As stated before, there was a need for a lab to be developed to meet our fourth outcome, as we did not assess this during the fall of 2015. We were able to tailor two labs to meet our fourth outcome the following semester. The Earth Systems Global and Energy labs received passing scores of 81% and 89% for the fourth outcome, respectively. On average, ENV5 102L students are showing an ~86% satisfactory score or above according to our outcomes. With the exception of the Oceanography lab, the results show that all labs are consistently above 80% satisfactory or above. Please note that some data was not provided by Teaching Assistants (marked as "no data" on our outcome spreadsheets). There is also a fair amount of missing data in sections 6 and 8 for the spring of 2016 due to technical difficulties regarding a Teaching Assistant's computer malfunctioning. During the spring of 2016 there is only a 4% rise in pass rates for the Oceanography lab,

which leads us to believe that there is a possible need for an intervention with pedagogy. Lower pass rates with this lab may also be a result of a poorly written assessment question. According to our Teaching Assistant's comments, we may need to adjust our expectations and thus our answer key for this specific summative question that is used for the Oceanography lab outcome assessment. As we have learned in the past, the more specific and detailed we can be with our questions, the more likely we will receive acceptable answers that can be reflected in our answer keys. The question for this lab will be rewritten for the class of fall 2016.

ENVS 102L Fall 2015

Section	1	2	3	4	5	S	U								
Outcome#															
1 - Sci Method (#1 - Hypothesis)	E 10	S 9	U 0	E 19	S 5	U 0	E 3	S 13	U 6	E 6	S 13	U 3	E 5	S 10	U 4
2 - Energy (#2 - Measurements)	2	8	9	10	5	5	3	14	2	6	12	4	2	17	2
2 - Rio Grande (#2 - Measurements)	15	4	0	7	10	1	4	10	7	10	7	1	25	13	0
3 - Rock Cycle (#3 - Observations to processes)	10	6	1	1	16	1	5	9	5	10	9	2	20	10	6
3 - Climate (#3 - Observations to processes)	7	11	1	9	5	7	5	9	5	10	9	2	20	10	6
3 - Atmosphere (#3 - Observations to processes)	16	2	2	11	1	8	6	11	3	13	8	2	5	35	2
3 - Earth Sys (#3 - Observations to process)	16	4	0	14	3	2	11	9	3	9	14	1	5	11	5
4**															
5 - Natural Hazards (#5 - evaluate environmental problem)	10	7	3	13	2	4	5	8	6	15	7	0	18	19	0
6 - Biogeochemistry (#6 - Field setting, use of equip)	2	16	4	3	5	9	3	13	4	7	13	3	0	15	5
7 - Groundwater (#7 - Interpret topo maps)	No data	No data	No data	1	14	4	7	7	4	3	10	6	10	28	0
7 - Topographic Maps (#7 - Interpret topo maps)	2	13	2	4	5	7	2	13	4	5	7	5	28	7	0
8 - Oceanography (#8 - use observations to apply to others)	2	5	11	5	9	8	6	8	6	3	16	3	4	22	15
4** Outcome 4 was not evaluated															

ENVS 102L Spring 2016

Section	1	2	3	4	5	S	U								
Outcome#															
1 - Sci Method (#1 - Hypothesis)	E 16	S 4	U 0	E 14	S 6	U 0	E 24	S 0	U 0	E 19	S 3	U 0	E 18	S 4	U 0
2 - Rio Grande (#2 - Measurements)	8	8	5	10	no data	4	17	0	3	6	2	10	no data	10	3
3 - Rock Cycle (#3 - Observations to processes)	8	11	1	10	9	4	17	0	3	5	11	4	6	10	3
3 - Climate (#3 - Observations to processes)	14	5	1	3	11	5	17	3	1	7	7	8	4	11	5
3 - Eco-Hydro (#3 - Observations to processes)	5	13	0	11	7	5	17	4	0	3	4	16	12	6	4
3 - Earth Sys Local (#3 - Observations to process)	8	10	1	16	4	3	21	1	0	17	4	2	15	6	0
4 - Earth Sys Global (#4 graph analysis)	14	8	0	no data	no data	2	20	0	0	7	1	10	no data	no data	0
4 - Energy (#4 graph analysis)	4	12	4	13	6	2	16	3	0	11	1	8	15	5	2
5 - Natural Hazards (#5 - evaluate environmental problem)	16	2	2	11	7	3	no data	no data	0	8	6	6	13	5	2
6 - Biogeochemistry (#6 - Field setting, use of equip)	12	6	2	2	16	4	21	0	4	0	19	3	2	14	5
7 - Groundwater (#7 - Interpret topo maps)	15	0	2	10	9	3	14	4	2	3	9	7	8	7	1
7 - Topographic Maps (#7 - Interpret topo maps)	2	8	10	6	8	7	11	2	0	3	15	3	10	6	4
8 - Oceanography (#8 - use observations to apply to others)	4	9	6	4	15	6	20	1	0	4	13	5	6	11	5

ENVS 102L Fall 2015

Section	
Outcome#	<p>1 - Sci Method (#1 - Hypothesis)</p> <p>2 - Energy (#2 - Measurements)</p> <p>2 - Rio Grande (#2 - Measurements)</p> <p>3 - Rock Cycle (#3 - Observations to processes)</p> <p>3 - Climate (#3 - Observations to processes)</p> <p>3 - Atmosphere (#3 - Observations to processes)</p> <p>3 - Earth Sys (#3 - Observations to processes)</p> <p>4**</p> <p>5 - Natural Hazards (#5 - evaluate environmental problem)</p> <p>6 - Biogeochemistry (#6 - Field setting, use of equip)</p> <p>7 - Groundwater (#7 - Interpret topo maps)</p> <p>7 - Topographic Maps (#7 - Interpret topo maps)</p> <p>8 - Oceanography (#8 - use observations to apply to others)</p> <p>4** Outcome 4 was not evaluated</p>

6	E	S	U	E	S	U	E	S	U	E	S	U	E	S	U
8	10	8	0	3	16	2	7	13	3	5	15	3	6	17	1
11	8	8	0	3	22	0	6	14	2	8	10	4	9	9	3
12	6	6	1	7	8	0	7	10	4	11	9	2	9	10	5
13	5	5	0	0	19	1	3	14	4	6	10	5	7	10	6
10	4	2	2	12	5	2	17	4	0	7	9	5	3	13	5
6	5	5	6	3	15	0	18	2	0	14	4	1	16	1	1
12	7	7	0	0	14	7	5	17	2	13	9	0	11	11	0
6	8	2	2	15	6	0	17	5	0	7	12	3	6	10	3
8	12	1	1	0	10	10	6	11	4	4	13	5	5	15	4
4	10	4	4	5	14	0	No data	No data	No data	10	7	5	12	7	4
11	6	0	0	14	5	0	1	15	5	8	5	6	9	7	6
No data	No data	No data	No data	4	11	5	13	5	0	4	7	11	3	8	9

ENVS 102L Spring 2016

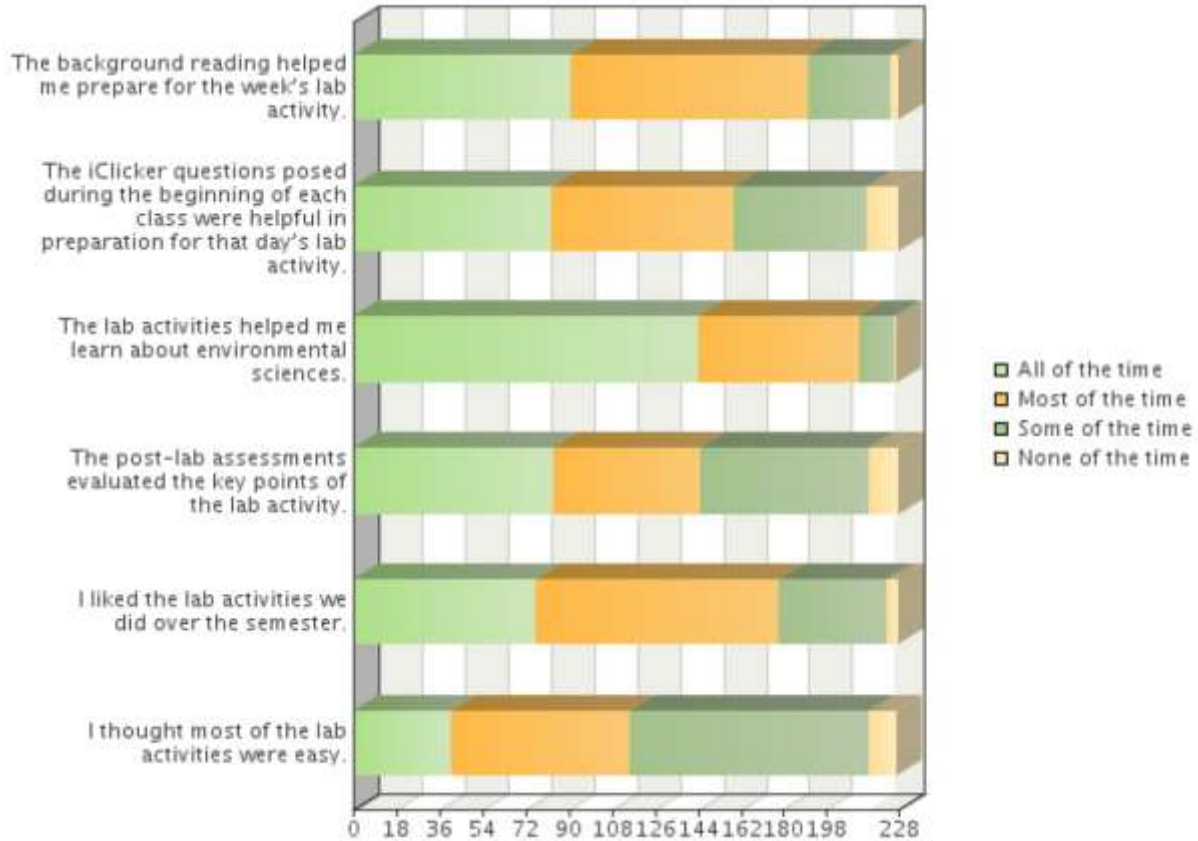
Section	
Outcome#	<p>1 - Sci Method (#1 - Hypothesis)</p> <p>2 - Rio Grande (#2 - Measurements)</p> <p>3 - Rock Cycle (#3 - Observations to processes)</p> <p>3 - Climate (#3 - Observations to processes)</p> <p>3 - Eco-Hydro (#3 - Observations to processes)</p> <p>3 - Earth Sys Local (#3 - Observations to processes)</p> <p>4 - Earth Sys Global (#4 graph analysis)</p> <p>4 - Energy (#4 graph analysis)</p> <p>5 - Natural Hazards (#5 - evaluate environmental problem)</p> <p>6 - Biogeochemistry (#6 - Field setting, use of equip)</p> <p>7 - Groundwater (#7 - Interpret topo maps)</p> <p>7 - Topographic Maps (#7 - Interpret topo maps)</p> <p>8 - Oceanography (#8 - use observations to apply to others)</p>

6	E	S	U	E	S	U	E	S	U	E	S	U	E	S	U
16	5	5	1	16	3	0	2	16	2	19	4	0	15	7	0
	no data	no data		6	7	3		no data	3	3	17	0	4	15	0
	no data	no data		13	5	1		no data	1	8	7	6	7	13	4
4	16	1	1	6	7	7	3	13	2	5	16	1	2	8	10
	no data	no data		14	5	7	3	no data	17	17	4	2	15	5	2
4	17	1	2	10	7	2	5	11	2	19	3	1	16	4	2
14	6	2		7	11	2	4	12	2	19	3	1	2	7	1
	no data	no data		12	5	4		no data	4	17	5	0	16	7	2
	no data	no data		8	8	3		no data	3	15	7	0	10	2	3
	no data	no data		11	5	5		no data	5	8	7	8	15	5	2
4	13	3	8	7	5	8	3	13	2	10	10	2	7	17	0

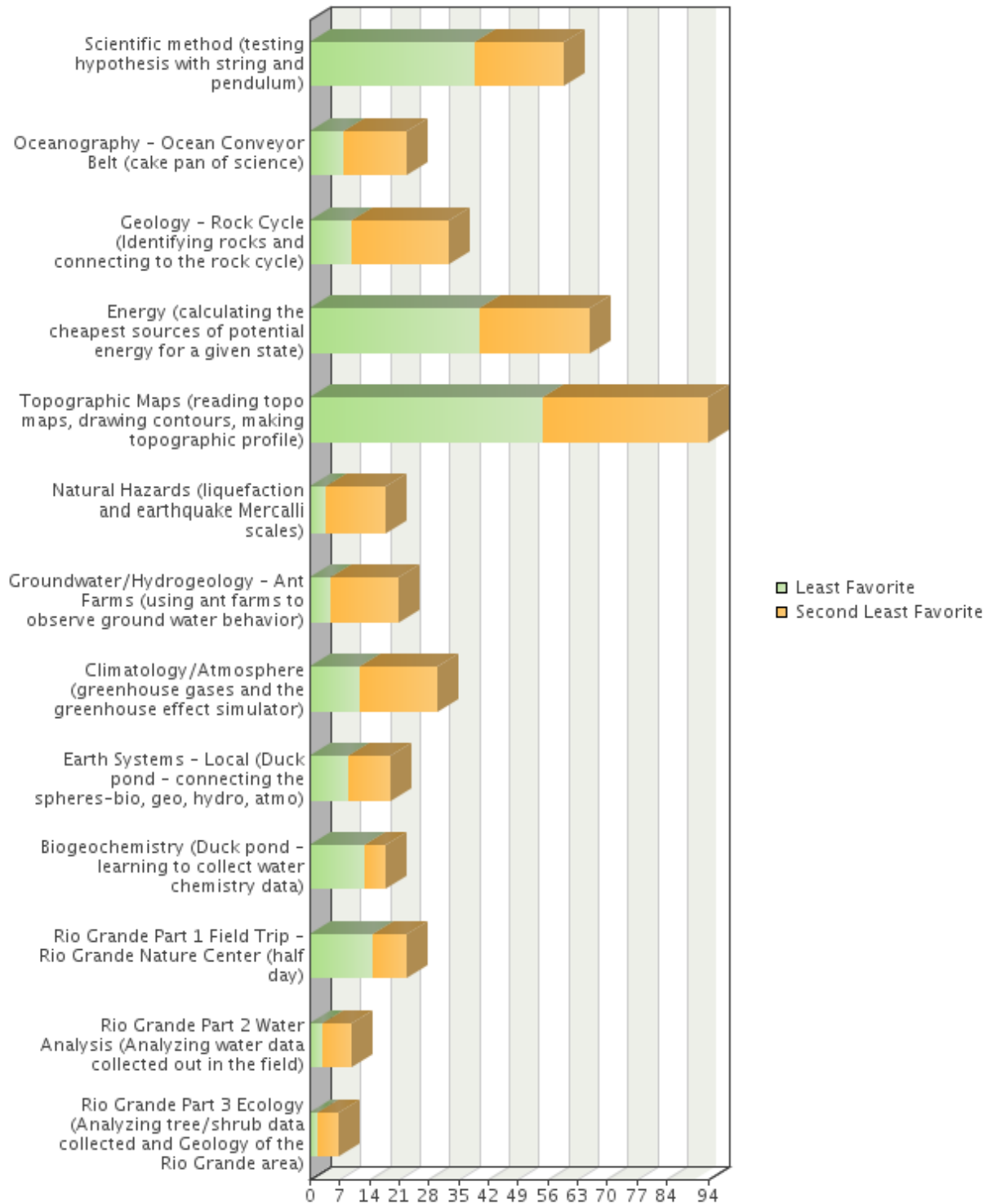


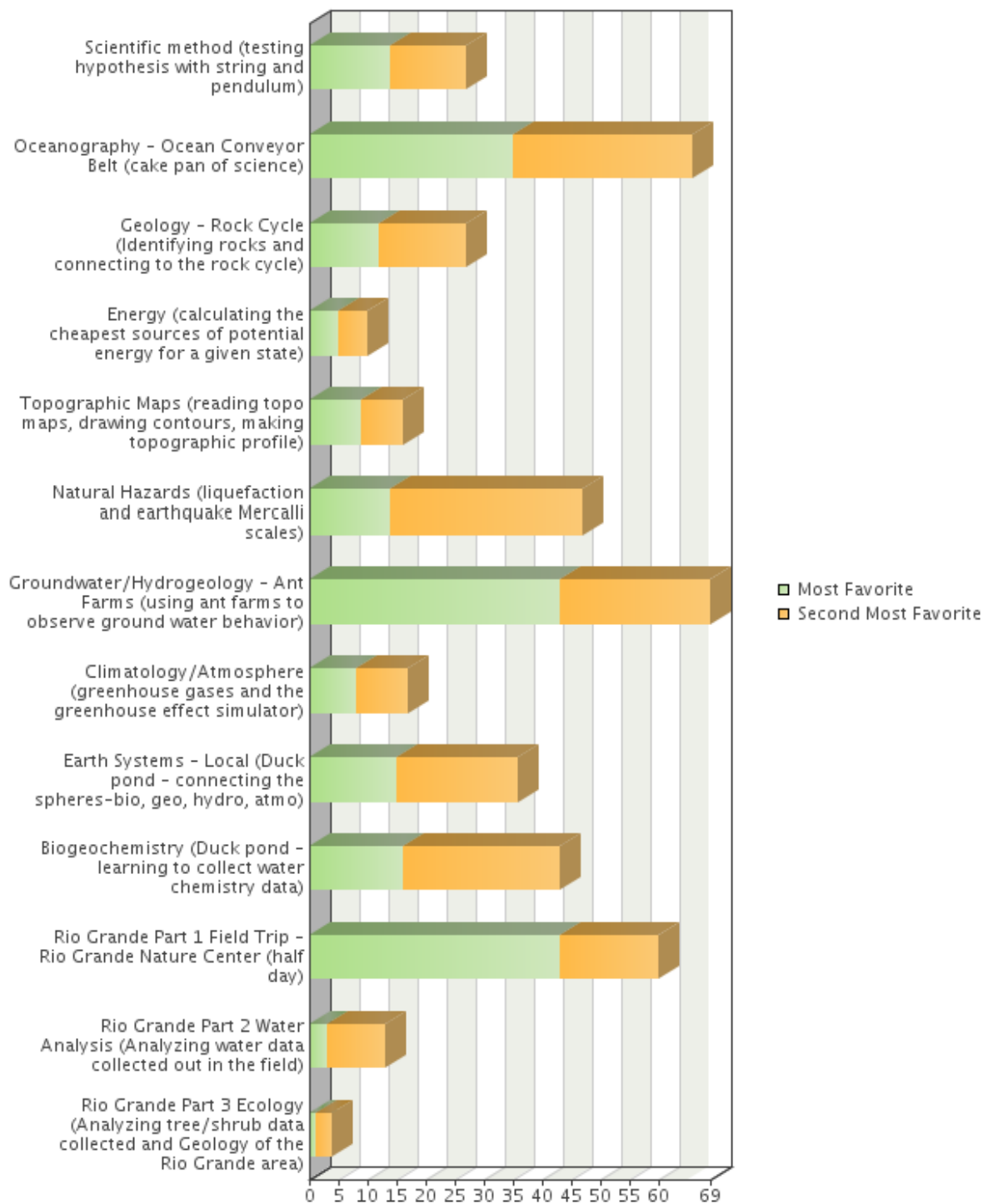


During the fall of 2015 and 2016, we also collected attitudinal data from our students. The survey responses indicate that students found the way the lab was designed help them to prepare for the upcoming week's lab and to improve their understanding of environmental science. Provided here is a sampling of the feedback provided by our students from the Spring of 2016.



We also asked students for their feedback on their least favorite and most favorite labs (see graph below). We used this information along with TA feedback to determine which labs needed changes, both curricular and pedagogical, to improve the labs for the Fall of 2016. Students also provided written comments on why these labs were their least favorite or most favorite.





5. Improvement:

Improvements are in progress as we review student and TA feedback for each of the labs. Future work also depends on whether or not labs are altered because that would alter assessments. All of our core

lab outcome results show that more than 72% of our students are meeting minimum requirements. As a result, one of our next steps is to evaluate how we can improve our success rates.

Approaches will involve redesigning labs and pedagogical changes to enhance and improve student learning as well as Teaching Assistant training regarding teaching and pedagogy. To accomplish this, we plan to redesign labs as needed. This will largely be based upon the responses we received from the students and the Teaching Assistants after each respective lab. The Teaching Assistants were able to answer questions in regards to whether or not the activity suited the outcome. All of the activities will be redesigned to some extent, be it the lab activity itself or one of the many components for a particular lab - .i.e. pre-lab assessments, post-lab assessments, iClicker questions, and background readings.

There are other challenges with teaching execution that will be worked on as we revise teaching guidelines which are also created for each individual lab. An example of a change in teaching technique was revising our lab on earth systems processes. Prior to receiving feedback from our Teaching Assistants, we asked several questions about the movement of carbon dioxide throughout earth's systems (geosphere, biosphere, atmosphere, and hydrosphere). The students struggled with this material because of their lack of knowledge regarding the carbon cycle. After receiving feedback, however, we were able to build in more carbon dioxide materials into the lab activity so there was an upward learning process. As a result our students were able to meet a higher level of understanding as shown in our outcomes data; there is a 5% increase in passing grades. During the summer of 2016, based on TA feedback, we decided to eliminate the earth systems lab, but incorporate the carbon dioxide information into another lab. To replace the earth systems lab, we added a new lab on plate tectonics. We have also re-written the geology lab, with feedback from our TAs. We plan to assess this change in the fall of 2016.

Although all labs, with the exception of the Oceanography lab, are above an 80% pass rate, we will still be aligning assessment questions with student learning outcomes in the coming months. We suggest that by evaluating each individual lab, we can improve the alignment with the stated outcomes, and thus the assessment of our outcomes and the lab itself. This is important in that our outcomes are not static, but rather dynamic in that we want to stimulate progress and foster improved student development practices in accordance to our goals. Ultimately, we want to improve pedagogy as well as the learning experience for our students.

To improve pedagogy, we have developed a workshop for all new introductory lab TAs for the Fall of 2016. This workshop will provide guidance on TA expectations for their responsibilities of running their laboratories as well as provide them with a pedagogical framework on how and why the labs were designed. We are hoping that if TAs understand how the labs are set up and why they were designed in this particular way, TAs will more likely see how they can contribute to student learning in their lab sections.

## 6. Expansion:

We anticipate teaching 14 sections of ENVS 102L in the Fall of 2016 and 12 sections in the Spring of 2017, which is the same for the previous fall and spring semesters. We cannot expand beyond 14 sections as we are limited by the number of hours we can teach in our present laboratory classroom,

which we share with Biology. We are allowed 2.5 days and we have filled it with 14 sections of the lab. We may be able to expand enrollments in the spring semesters from 12 to 14, as we have student demand, but we may not have enough TAs to teach the courses. The instructors will continue to be Teaching Assistants.

7. Sustaining:

All of the materials that have developed for the course, including materials from previous iterations of the labs are curated with the Coordinator of the labs. If there is an anticipated change in coordination, then the curated materials would be transferred to the new coordinator. All of the materials provided to the Teaching Assistants are housed in DropBox for use during the semester in which they are TAs for the course. The redesign team is continuing to assess outcomes and make adjustments to the labs and associated materials for continuous improvement. Since all of the materials are curated, the redesign course elements can be transferred and used by anyone who coordinates or teaches the labs.

8. Challenges:

One of our major challenges is that the labs are taught by TAs, and these TAs change from semester to semester. This requires training every semester for any TA that has not previously taught the lab, and re-training and/or encouragement to returning TAs to improve their pedagogy for the new semester.

Since TAs change semester to semester, the TAs are not always invested to follow the pedagogy or to provide feedback to improve the labs. This can be challenging to the redesign team, as we are not directly teaching the labs but relying on participation by, and constructive feedback from, the TAs for continuous improvements.