Course Title: BIOEN 404 – Bioengineering Team Design I

BIOEN 405 – Bioengineering Team Design II

Instructors: Chris Neils and Alyssa Taylor

Credits: BIOEN 404: 3

BIOEN 405: 3 (converting to 4)

UW General Catalog Course Description:
404: First course in team design project course sequence. Prerequisite: BIOEN 401.
405: Second course in team design project course sequence. Prerequisite: BIOEN 404.

Detailed Course Description:
The Department of Bioengineering offers two options for completing a senior capstone project. Students who choose the BIOEN 401-402 sequence conduct an individual design project. Students who choose the BIOEN 401-403-404-405 sequence conduct an individual research project and a team design project. The number of total credits in each sequence is equal.

BIOEN 404 and BIOEN 405 form a two-quarter design sequence for bioengineering majors, running through winter and spring quarters. This design sequence complements the BIOEN 403 Bioengineering Capstone Research course to provide comprehensive experience with the application of bioengineering principles to solve real-world problems. BIOEN 404/405 students work in 2-5 person teams to design, create, and test a system, device, or process that addresses an unresolved medical or health-related problem. The faculty instructor will identify and develop projects prior to the start of BIOEN 404. Projects will be sought from the broader health care community, including School of Medicine, School of Nursing, College of Engineering, and local industry. Where possible, the faculty, clinicians, or industry representatives will provide in-kind funding and mentorship for the student groups. Projects without such dedicated sponsorship will be supported to a limited extent by departmental funds or education grants.

During BIOEN 404, the instructor will present the project topics, assign teams, and provide guidance on project planning and execution. Lecture topics may include intellectual property issues, regulatory affairs, design for low-resource settings, design case studies, and prototyping techniques, although some of these items may be covered in BIOEN 401. Instruction with lab practice will be offered in technical drawing. Machine shop instruction will be provided on a space-available basis. During BIOEN 404 students will request assignment to project teams, develop and present design strategies for their assigned projects, and complete homework related to the various lecture and lab topics listed above. By the end of the quarter each student group should have a design concept, system specifications, a budget and a timeline that will be carried out during the following quarter.

BIOEN 405 is devoted primarily to the detailed design and production of the project deliverables. Students may work in Bioengineering student labs, UW instrument fabrication shops, or facilities provided by their project mentors, as space and student qualifications permit. Depending on the availability of funds and the complexity of the project, students may also pay

professional instrument makers to build parts to the detailed specifications provided by the student groups. The team capstone instructor will monitor student progress and provide both technical and strategic guidance as necessary. Students will submit progress reports and a final paper describing the design process and project outcome, with a presentation and demonstration of the final product. When time and funding permit, students will be invited to test each product in its intended location, for example in a hospital setting or in a rural community.

The team design project is intended to satisfy the ABET requirement for a culminating design experience. The design content should be consistent with the ASEE white paper, *Design versus Research: ABET Requirements for Design.*[1]

The BIOEN 404 grade is based on the following:

Timeline, patent search, and draft proposal (team)	15%
Progress presentations (individual)	10%
Written project proposal (team)	40%
Individual section of proposal	20%
Oral presentation of proposal (team)	10%
Cross-project critique (individual)	5%

The BIOEN 405 grade is based on the following:

Assignments (individual)	20%
Final written report (team)	30%
Final oral presentation (team) and exam (individual)	30%
Peer evaluation of group work performance	10%
Class Participation	10%

Prerequisites by Topic:

Circuit analysis, differential equations, physics (mechanics, E & M). Requires Bioengineering Capstone Principles (BIOEN 401) or permission of instructor.

Textbooks: None

Learning Objectives:

- Learn the strategic and technical skills needed to plan and conduct bioengineering projects.
- Develop design skills that may be applied to a variety of bioengineering devices.
- Integrate skills and knowledge learned throughout curriculum by completing an open-ended project with recognizable implications for healthcare.
- Learn the importance of effective medical care through the process of addressing unresolved medical needs.
- Develop interpersonal skills that promote effective team design skills.

[1] Gassert *et al*., 2006, accessed via http://soa.asee.org/paper/conference/paper-view.cfm?id=1341.

Topics Covered:

Design of experiments, tools, and devices. Composition of design proposals and project reports. Podium and poster presentations. Specialized topics and techniques as appropriate.

Class Schedule:

BIOEN 404 (winter quarter) meets twice weekly with 1-hour periods for lecture and discussion, plus once weekly for a 2-hour lab period. BIOEN 405 (spring quarter) meets twice weekly with 1.5 hour periods for individual guidance or student presentations. Students are expected to contribute significant effort outside of class to the design and development, and the instructor is expected to provide significant office or lab hours to provide consultation.

Computer Use:

Coursework requires the use of computer-aided design (CAD) tools and test systems, including AutoCAD, LabView, and similar software environments. Engineering experimentation requires computer-based data analysis. Projects may require numerical simulations, signal and image processing, and advanced programming depending on the particular research projects. Standard desktop software is used for communication and report preparation.

Laboratory Projects:

Students work in 2-5 person teams to design, create, and test a system, device, or process that addresses an unresolved medical or health-related problem. Brief computer-aided drawing and fabrication projects may be assigned as learning exercises.

Course Outcomes and Assessment:

In this cumulative design experience, students will develop a variety of important engineering and professional skills. As such, this course addresses the following ABET outcomes:

[c] *Design a system, component, or process to meet desired needs within realistic constraints that may be economic, environmental, social, political, or ethical, and may include health, safety, manufacturability, and sustainability.*

Throughout this project, students are working to design a system to meet a desired need within identified realistic constraints. Students work with their team and advisor to identify the constraints relevant to their design problem, and work for two quarters to design a solution to meet the need (identified through first-hand observations, interviews with users, etc.). Student competency will be assessed through the final oral project presentation and an individually-based final oral exam session.

[d] *Function on multi-disciplinary teams.*

Student design teams are formed by the instructors and may contain a member from outside BIOE. For example, in 2011-2012 a student from Industrial Design was included in an AED design team. Also, within the field of bioengineering, there are many sub-disciplines. All BIOE students have taken the same core courses but through lab experiences, electives, dual majors, internships, etc. are able to specialize in different areas of BIOE. In this course, students with different backgrounds and interests learn to function effectively as a team to complete an extensive project. Student competency will be assessed through individually-based oral progress reports and peer evaluation of group work performance.

[e] *Identify, formulate, and solve bioengineering problems.*

In this course, students execute key steps of the engineering design process, including identification of the problem, exploration and formulation of the problem, and design of a

solution. Students learn how to identify and conduct thorough research on current bioengineering problems, and work in teams to propose and design solutions to those identified problems. Student competency will be assessed through the final oral project presentation and an individually-based final oral exam session.

[j] *Demonstrate and apply knowledge of contemporary issues.*

Each student team works to solve a contemporary bioengineering-related problem. Student competency will be assessed through an individually-based section of the written proposal, in which students must discuss the current cost or consequence of not having the proposed technology, as well as current economic, ethical, social, legal, and regulatory issues relevant to the proposed technology.

[n] *Make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems.*

As many of the projects are proposed by clinicians or biomedical researchers, design projects involve the interaction between living and non-living materials. Testing and validation of the design involves making measurements on living systems. Student competency will be assessed through an individually-based written assignment involving a description of the generation of a testing plan and resultant test data for their project.

Relationship of Course to Program Educational Objectives:

This course allows students to apply the Bioengineering fundamentals they have learned, and to learn advanced topics and techniques, in a manner consistent with graduate and professional training in medicine and biology. The student projects are typically originate as suggestions from clinicians or industry experts, and therefore address immediate or long-term issues that are of considerable importance to human health. Students may encounter problems that require knowledge from any or all of their prior courses or that may require them to master concepts that they have not previously explored. Students must communicate their progress to their instructors, collaborators, and peers, who may encompass a broad range of academic and professional backgrounds. Students in BIOEN 404-405 progress toward our departmental objectives because they are required to manage a team design project with real-world relevance. They develop written and oral communication skills, technical expertise, and engineering design knowledge. Completion of their project allows students to gain key professional and research skills that they will need to obtain employment in bioengineering-related fields. Working with an advisor from medicine or industry, students must be responsible and guide the progress of their own projects. They gain experience in project management, working in an interdisciplinary team, and conveying their ideas to their peers and supervisors. Students gain practice in transferrable professional tasks such as proposal writing and oral presentations. As such, this experience will give students many tools needed to reach the program educational objectives of the Department of Bioengineering:

- Pursue educational opportunities and/or employment in bioengineering-related fields, such as medicine, device development, or biotechnology.
- Pursue opportunities for professional growth and development.
- Serve their profession and community.
- Contribute to responsible development of new technical knowledge.
- Take leadership roles in addressing domestic or global bioengineering-related issues.

Typical BIOEN 404 Winter Quarter Schedule

See courses.washington.edu/bioeteam for the most recent schedule.

Week	Topic	Assignment due
1	Class introduction. Review of project topics, including project-specific IP issues and technology. During 402/403 class: Lecture on redundancy, reliability, and safety margins.	
	1st half: Lecture on documentation and using a lab notebook (see video link on C4C IP page). 2nd half: meet in project groups to develop timeline.	
	Group work period, ideally meeting with mentors.	
2	During 404 class: project lab setup. During 402/403 class: mini-lecture on statistics.	Time line
	Intro to, and work time on, literature & patent searches.	
	Team work time	
3	Groups present literature and patent search results.	Patent search
	Team work time	
4	Lecture: Preparing design proposals / progress reports; design competitions	
	Progress presentations I (individual, one per group)	
	Team work time	
5	During 402/403 class: Guest lecture on FDA regulation.	
	Lecture: Software regulation and documentation	Proposal outline
	Team work time	
6	During 402/403: Lecture on materials selection (Taylor)	
	Progress presentations II (one student per group)	
	Team work time	
7	*No class – Presidents' Day*	
	Lecture: Design for high-resource settings, profit & marketing, presented during BIOEN 402/403 class.	Draft proposal, for comments
	Team work time	
8	Team work time	
	Lecture: Design for low-resource settings	
	Team work time	
9	Progress presentations III (individual, one per group).	Current draft of Written proposal
	The 9:30 class period is work time.	
	Team work time: prepare for presentations	
10	Team proposal presentations during 402/403 class	
	Maintaining project continuity over winter break; Course evaluations	Critique of presentations
	Team work time: finish/submit written proposals	Final written proposal

Typical BIOEN 405 Class schedule* (Spring quarter)

Day	Topic	Assignment due
1	Welcome, syllabus review, project status report	Informal project status reports (team)
2	Documenting device designs	
3	Team work day	
4	Generating a testing plan	
5	Market analysis	
6	Team work day	
7	Materials selection	Notebook check
8	Design for manufacturing	
9	Design solutions workshop	Written progress report
10	Team work day	
11	Mid-quarter formative assessment	
12	Oral presentation guidelines	Report draft (team)
13	Team work day	
14	Current events in IP, technology, and regulation	Notebook check
15	Final Oral Presentations, including Prototype demonstrations (team) and Exam (individual)	Final Oral Presentations and Oral Exam
16	Prototype revisions (return report draft comments & instructor feedback to students on oral presentations)	Written response to instructor feedback
17	Center for Instructional Development and Research: BIOEN program evaluation	
18	Your project as a job-seeking tool/interviewing	
19	Team work day	
20	Wrap-up; Course evaluations	Final written report (team) & Test Data component (individual)
21	*Final exam period : no exam*	Peer evaluation

*Topics may be adjusted per student interest and project relevance.

Instructors will be available during team work days to provide assistance and will hold frequent office hours.

BIOEN 404 assignments

Time line: Document showing when you plan to execute the various stages of the design process. May be generated in Excel, Word, or MS Project. This is a living document and should be reconsidered and revised as necessary before each individual progress presentation.

Patent/literature search: Each team member should choose one patent or patent application that is relevant to the design project. Include the number and title, at least one figure (which can be taken from the patent), a summary of the patent's claims, and a commentary on its implications for your project. If you have found other patents of interest include their numbers and titles only. The target length is 1 page per patent. Please submit one combined document per team.

Proposal outline: Using the "Required Elements for the Team Capstone Proposal" provided in this syllabus as a starting point, add as much detail as you know so far in bullet form. This document serves both as a starting point for the proposal and as an impetus to consider steps in the complete design process.

Proposal draft 1: This draft should include the device overview including specifications, available technology, technology to be used, test methods, and design timeline. Length will vary by group, but it is reasonable to expect 3-4 pages of text plus 2+ pages of figures plus one-page timeline. To be submitted for comment; scored on completeness rather than content.

Proposal draft 2: Similar to proposal draft 1, but comments on draft 1 should be incorporated. Otherwise this can be an "as-is" document; it is primarily used by the instructors to prepare questions for the proposal presentations.

Formal/final written proposal: similar to design proposal in BIOEN 401. See the detailed outline elsewhere in this syllabus. Most of the document is to be written as a team, but a portion is to be written and submitted separately by each individual team member.

Podium presentation of proposal: Present background and proposed design to senior class.

Critique of presentations: 1-page commentary on technical and communication aspects on the other teams' presentations.

BIOEN 405 assignments

Notebook: Twice during the spring quarter, each student will submit the design notebook to the instructor for review. Multiple turn-in dates will be given to fit students' schedules.

Prototype critique: 1-page analysis of design and implementation of two devices.

Peer review: 1-page review of the contribution of each of the team members to the device design and prototyping process. Each student will receive a score based on the completeness and professionalism of the critique, and a score based on the opinions of the other team members.

Report draft: Draft of final report. Provides opportunity for instructor to gauge student understanding and provide feedback.

Test data assignment: Individually-executed assignment on generation of testing plan and resultant test data.

Final report: see detailed format & outline below.

The final Capstone Project Proposal defines the work to be done to design, build, and test a prototype, as well as the motivation for the project. The project proposal obviously incorporates design, but may include description of any research that is necessary to accomplish the design build project.

Required Elements for the Team Capstone Proposal

Cover page

- *Title*
- *Names of Students*
- *Name of primary mentor (not 404-5 instructors)*
- *Date*
- *Project summary (1 paragraph)*

Background and Significance (probably 4 pages + graphics)

- *Statement of Problem*
- *Review of methods or devices currently in use*
- *Review of intellectual property / patents*
- *Review of ongoing design work elsewhere; if none, state so*
- *Critical evaluation of existing approaches and design work*
- *The current cost or consequence of not having this technology*
- *Other benefits or consequences of success, if any*
- *Barriers to implementing the technology*
  - *Technological challenges (might be better later in paper)*
  - *Economic, Ethical, Social, Legal and Regulatory Issues*
  - *Briefly touch on all; describe the most applicable in depth**

** The underlined portion is to be written as an individual assignment, i.e. four of these sections are to be turned in per proposal.*

Plan of Work (probably 4 pages + graphics)

- *Specific design goal (more applicable if you have a lot of leeway in your goals)*
- *Design overview*
- *Materials, methods, and specific tasks to be performed*
- *Deliverables (devices, processes, systems, software, or reports, as appropriate)*
  - *Phase 1 (necessary product)*
  - *Phase 2 (desired product)*
- *Anticipated decision points, problems, and planned workarounds*
- *Methods to evaluate product, including statistical basis and analysis strategy*
- *Resources (funds, equipment, supplies, animals, patients, samples, information, software, etc.) used so far and needed in the future to carry out work*

Timeline: Table or Gantt chart (1 page)

Key personnel (may be put in another section if it fits better)

References

More details on the team capstone project proposal (written and presentation)

Format: The preferred format is 1.5-spaced 12 point Lucida Fax, Cambria, Verdana, Leelawadee, Trebuchet, Arial, Calibri, Candara, Rockwell, or Tahoma, left (or inside) margins of 1.25 inches, and other margins of 1 inch or less. It should be submitted as a Word document so it can be edited and commented in electronic format. It is to be written in formal scientific English; style, formatting and proofreading count.

The team must also have their advisor submit an e-mail stating that the advisor has read and approved the plan (or a draft thereof), to be received by the same due date as the final proposal.

Scoring breakdown for written proposal

Cover page, refs, time line†	10
Background and significance†	15
Design†	20
Design strategy*	15
Identify and formulate problems*	15
Quality of writing & proofreading*	15
Explanation of current issues*	10
Total	*100*

†Score primarily for completeness

*See additional detail in rubric table.

In-class oral presentation of capstone proposal (10+5 minutes)

Completeness of spoken part	5
Logical sequence and transitions	5
Oral communication skills	5
Completeness of slides or other visual/tactile aids	5
Quality of presentation slides (visual interest, readability)	5
Ability to answer questions from audience	5
Total	*35*

Note that the **Consequences of Success** section of the proposal should describe the process of translation of the design to a commercial product (target population for use (including country/culture), mode of use of the product, manufacturing and scale-up challenges, definition of customer and expected sales revenue in first 5 years). Social and ethical issues discussions could include pre-existing and new ethical concerns, cultural context of end-use scenarios, psychology of use, marketing, advertising and public relations strategy. Legal and regulatory issues should include a discussion of the intellectual property landscape (patents and licenses), regulatory path, and liability issues.

Team Capstone Design Proposal grading rubric – general criteria

ABET outcome	Objective	4 Exemplary	3 Proficient	2 Apprentice	1 Novice	Score
c	**Design a system, component, or process to meet desired needs:** Propose a device, system, process, etc. for completion in BIOEN 405. (See note 1)	Proposal clearly defines need, constraints, and design specifications. Multiple options to overcome anticipated obstacles are considered. Proposed design is detailed and seems likely to succeed.	Proposal addresses need, constraints, and design specifications, but not thoroughly. Some consideration given to overcoming obstacles. Proposed design is plausible, considered in some depth.	Proposal weakly addresses some need, constraints, or design specifications. Obstacles are not considered. Proposed design is a long shot, or weakly developed.	Proposal omits needs, constraints and specifications. Design is blatantly unfeasible. [Zero: no design proposed]	
e	**Identify, formulate, and solve BioE problems:** Recognize need in medical or bioscience community; evaluate its relative and absolute importance; cast problem as an engineering challenge. (See note 1)	Medical or scientific need is clearly explained; current costs (health, economic, social, etc.) and potential side benefits are used to justify project; problem is cast as engineering challenge.	Medical or scientific need is clearly stated; current costs (health, economic, social, etc.) are mentioned; problem is cast as engineering challenge.	Medical or scientific need is stated; some current costs are mentioned; engineering design may be inappropriate for challenge.	Need is not clear, relevance of engineering is not addressed, proposed design would not satisfy need.	
g	**Communicate effectively:** Prepare detailed written report that addresses engineering, economic, and societal issues.	Written report is virtually error-free, logically presents project, is well organized and easy to read, contains high **quality** data/graphics,	Report is logically presented, well organized, easy to read, contains high quality data/graphics, and contains few minor grammatical and/or rhetorical errors; link between need and proposed design is apparent.	Report is generally well written but contains some grammatical, rhetorical and/or organizational errors; project is not fully explained.	Report does not present project clearly, is poorly organized and/or contains major grammatical and/or rhetorical errors. Does not link need to proposed design.	
j	**Demonstrate knowledge of contemporary issues** surrounding the design, such as environmental, social, legal, ethical, geopolitical consequences.	Identifies a number of important E, S, L, E, G considerations; evaluates strengths & weaknesses of most relevant categories, including present and future ramifications.	Identifies a number of important E, S, L, E, G considerations; includes limited discussion of the strengths & weaknesses of most relevant categories, including present ramifications.	Identifies a few of the obvious E, S, L, E, G considerations with shallow discussion of the ramifications.	Lists E, S, L, E, G considerations with no discussion of the ramifications.	

1. "Need" is included in both outcomes C and E. To get points in C, the need should be briefly identified; emphasis is on constraints and specifications. To get points in E, the need should be explained in detail.

BIOEN 405 Project Report

Please see detailed requirements, description, and grading rubric posted on the course website. Briefly, the final report will be a technical document describing the need for the project, its design constraints, the design process, the selected design, the implementation of that design, and the results of testing. The document should be in 12-point Times or an equivalent font, 1.5-spaced, with 1" margins. The number of pages proposed is merely a guideline and is neither a minimum nor maximum. (Grading will be based on content, not length.) All writing is to be in formal technical English.

The team design final report should include the following content:

Cover Page (1 page)

- Title of the project, course name, names of all team members.
- Briefly describe each team member's contributions and roles in the project.

Abstract (.5 page)

Problem Statement and Description (.5 - 1 page)

Market Analysis (.5 - 1 page)

Prior Art (1 - 2 pages)

Design Specifications (1 page)

Solution Generation and Selection (2 pages)

Results: Design Description (2 - 3 pages)

Results: Test Data (Submitted separately by each team member, 2 - 3 pages)

- Describe generation of testing plan and the resultant test data; see separate assignment description and rubric.

Ethical and Societal Considerations (.5 - 1 page)

Global and Societal Impact (1 page)

Regulatory Issues (.5 page)

Conclusions (1 page)

Future Work (.5 page)

References

Acknowledgements

Appendix (2 pages)

- Gantt Chart
- Costs Table

Supplemental figures, data, programs, CAD files, etc., may be made available on a web site or uploaded to BIOEN 405 course Collect It dropbox.

The final report is to be graded by the team design instructor. Grading of class components overall will be based on the criteria in the attached grading rubric; criteria should be equally weighted.

Grading Rubric for Bioengineering Capstone Team Design Project

Students: _____ Date: _____

Project Title: _____

Each BS BIOE graduate will conduct a design project in teams and prepare a written report and oral class presentation that show the ability to…

ABET outcome	Objective	4 Exemplary	3 Proficient	2 Apprentice	1 Novice	Score
c	**Design a system, component, or process to meet desired needs:** Apply design plans developed in BIOEN 404; modify and improve based on experimental results.	Design adaptations based on acquired results are considered to better adapt the design to the desired needs. More than one option is considered and tested and the best option is utilized.	Design adaptations based on acquired results are considered to better adapt the design to the desired needs. At least one alternative is considered and tested.	A design adaptation based on acquired results is considered to better adapt the design to the desired needs. One alternative is considered but not tested.	Original design followed without considering modifications.	
d	**Function on multi-disciplinary teams:** Work effectively in teams to complete project goals.	Team member fulfills assigned roles during execution of team design project without having to be reminded, assists others, consistently does what he/she was supposed to or went beyond obligations; very well prepared, respectful, and cooperative.	Team member performs duties that are assigned, listens to teammates most of the time, usually cooperative and prepared for meetings.	Inconsistently performs duties that are assigned, may not allow others to speak or share ideas; cooperation with teammates is lacking.	Always relies on others to do the work, never listens to other teammates, does not perform duties of assigned team role.	
e	**Identify, formulate, and solve BioE problems**: Recognize need in medical or bioscience community; evaluate its relative and absolute importance; cast problem as an engineering challenge; demonstrate device or process that addresses the problem.	Medical or scientific need is clearly explained; current costs (health, economic, social, etc.) are used to justify project; problem is cast as engineering challenge; device or process is shown to be an effective solution.	Medical or scientific need is clearly stated; current costs (health, economic, social, etc.) are mentioned; problem is cast as engineering challenge; device or process is shown to be an effective solution.	Medical or scientific need is clearly stated; some current costs are mentioned; engineering design may be inappropriate for challenge; device or process is implemented but is only partially effective.	Need is not clear, problem is not addressable by engineering solutions, and/or the project does not satisfy the stated needs.	
g (not assessed)	**Communicate effectively:** Prepare detailed written report that addresses engineering, economic, and societal issues; demonstrate device or process for class.	Written report is virtually error-free, logically presents project, is well organized and easy to read, contains high quality data/graphics, and draws conclusions supported by presented data. Product demonstration is well organized, clear, and informative.	Report is logically presented, well organized, easy to read, contains high quality data/graphics, and contains few minor grammatical and/or rhetorical errors. Conclusions drawn from presented data. Product demonstration is adequately organized and informative.	Report is generally well written but contains some grammatical, rhetorical and/or organizational errors; project is not well explained and not fully discussed. Questionable conclusions made based on presented data. Product demonstration is not well organized and confusing.	Report does not present project clearly, is poorly organized and/or contains major grammatical and/or rhetorical errors. Data does not support conclusions, or conclusions not presented. Product does not perform desired task and presentation is not informative or is painful to watch.	

Grading Rubric for Bioengineering Capstone Team Design Project

Students: _____ Date: _____

Project Title: _____

j	**Demonstrate knowledge of contemporary issues** surrounding the design, such as environmental, social, legal, ethical, geopolitical consequences.	Identifies a number of important E, S, L, E, G considerations; evaluates strengths & weaknesses of each category, including present and future ramifications.	Identifies a number of important E, S, L, E, G considerations; includes limited discussion of the strengths & weaknesses of each category, including present ramifications.	Identifies only a few of the obvious E, S, L, E, G considerations with shallow discussion of the ramifications.	Lists E, S, L, E, G considerations with no discussion of the ramifications.	
n	**Make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems**	Student clearly knows what parameters need to be measured and is proficient at more than one type of measurement to address the problem. Student is familiar with the advantages and disadvantages of all the methods.	Student is aware of what parameters need to be measured and is proficient at least one type of measurement. Student is familiar with the advantages and disadvantages of this type of measurement.	Student is aware of how to make at least one type of measurement and interpret the data. Student does not clearly understand the advantages and disadvantages of this measurement or how it addresses the interaction between living and non-living materials and systems.	Student unclear on how to make measurements or interpret the data. Report does not address problems involved with interaction between living and non-living systems	