Program Outcomes and Assessment

Degree Program: BS Biology (Department of Natural Sciences)

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Program Mission Statement:
The mission of the Department of Natural Sciences is to provide a comprehensive science education to the students of CSU, and to provide public service to the residents of the Atlanta Metropolitan Area.

The mission is accomplished by providing

1. Bachelor degree programs that provide preparation for the workplace and graduate or professional schooling.
2. Core curriculum courses that provide a scientific perspective for all graduates of Clayton State University.
3. Programs of study in science disciplines for which CSU does not have bachelor degree programs that provide preparation for transfer to bachelor degree programs.
4. Service courses for Health Sciences and Teacher Education that enhance those programs.
5. Support for science-related activities in the university's service area.
6. Research in support of education or professional development.
7. Continued professional development of all faculty.

Learning Outcomes:
After completing the B.S. in Biology Program at Clayton State University, graduates will

1. Effectively demonstrate knowledge of the basic principles of major fields of biology.
2. Demonstrate a mastery of a broad range of basic lab and technology skills applicable to biology.
3. Apply knowledge of physical sciences, mathematics, and statistics to biological concepts.
4. Communicate scientific information in a clear and concise manner both orally and in writing.
5. Demonstrate the ability to collect, evaluate and interpret scientific data, and employ critical thinking to solve problems in biological science and supporting fields.
6. Collaborate effectively on team-oriented projects.
7. Demonstrate the ability to identify and describe the impact of biological and physical sciences on the environment and society.

Assessment Methods/Type of Evidence:

Direct Methods

Learning Outcome	Assessment Method (Data Collection)
1	Major Fields Test in Biology (ETS Exam)
2	Laboratory Practical and Skills Tests: Microbiology Skills Molecular Biology Skills Organismal Biology Skills Chemistry Skills
3	Embedded Questions on Exams and assignments
4 (oral)	Rubric used to score oral presentations
4 (written)	Rubric used to score written work
5	Major Fields Test (Analytical Section) Embedded questions on exams Laboratory Reports
6	Rubric used to score team work
7	Embedded Questions on Exams

Indirect Methods

Learning Outcome	Assessment Method
1-7	Student evaluations of courses question number 7
1-7	Exit interview
1-7	Alumni survey
2	Lab and computer skills competency checklist

Data Collection Overview

Direct Methods

Learning Outcome	Assessment Method/Type of Evidence	When/Where will Data Collection Take Place	Who will collect data
1	Major Fields Test in Biology (ETS Exam)	BIOL 4999A (taken by all students in their last semester who completed all upper division course work at CSU)	Biology Coordinator (Jordan)
2	Laboratory Practical and Skills Tests: <u>Microbiology Skills</u> (Streak Plate, Smear Preparation, Smear Staining, Aseptic Technique, Microscope Focusing) <u>Molecular Biology Skills</u> (Preparation of Solutions, Gel Electrophoresis, Pipetting) <u>Organismal Biology Skills</u> (dissections) <u>Chemistry Skills</u> (use of buret, analytical balance, melting point, IR spectroscopy, performing recrystallization) <u>Computer Technology</u>	 BIOL 3250L BIOL 4202L BIOL 3650L CHEM 1211L, CHEM 2411L BIOL 4900	 Furlong Jordan, Norflus Burnett Agyeman, Clower Furlong, Jordan, Clower, Burnett, Singiser
3	Embedded Questions on Exams and assignments	BIOL 3250, BIOL 4900, CHEM 4202, BIOL 4202L, BIOL 3380, BIOL 1107L, BIOL 1108L	Furlong, Burnett, Singiser, Clower, Norflus, Jordan, Melvin
4 (oral)	Rubric used to score oral presentations	BIOL 4900, BIOL 4222	Furlong, Clower, Jordan, Burnett, Kodani, Singiser

4 (written)	Rubric used to score written work	BIOL 3380, BIOL 4450, BIOL 3650, CHEM 1212L, CHEM 4205	Burnett, Norflus, Taglialatela, Todebush, Singiser
5	Major Fields Test (Analytical Section) Embedded questions on exams Laboratory Reports	BIOL 4999A BIOL 3250 BIOL 3250L, BIOL 4202L, BIOL 1107L, BIOL 1108L	Biology Coordinator (Jordan) and Dept. Chair, Furlong Furlong Jordan, Melvin, Furlong, Burnett, Norflus
6	Rubric used to score team work	BIOL 4900, BIOL 3380	Furlong, Singiser, Clower, Jordan, Burnett
7	Embedded Questions on Exams	BIOL 3500, BIOL 3250, BIOL 3550, BIOL 4930	Kodani, Furlong, Melvin and Jordan

Indirect Methods

Learning Outcome	**Assessment Method/Type of Evidence**	**When/Where will Data Collection Take Place**	**Who will collect data**
1-7	Student evaluations of courses question number 7 ("The Course contributed toward the attainment of my educational and career goals."	All courses taken at CSU	Department Chair, Furlong
1-7	Exit interview.	BIOL 4999 A and B	Biology Coordinator, Jordan
1-7	Alumni survey.	Distributed 3 years post graduation	Department Chair, Furlong
2	Lab and computer skills competency checklist.	BIOL 4999 A and B	Biology Coordinator, Jordan

Discussion of Results and Changes

Learning Outcome 1

Direct Assessment

Learning Outcome 1 is measured by using the Biology Fields Test developed by the Educational Testing Service (ETS). This exam is given to Biology majors who completed their upper division Biology courses at CSU. We have designed our curriculum so that the students should be prepared in all of the major fields of Biology. There are 4 content subdivisions in this exam (Cell Biology—S1, Molecular Biology and Genetics—S2, Organismal Biology—S3 and Population Biology/Evolution/Ecology—S4). We have compared the institutional mean scores of these students in each of these subdivisions to the National mean scores each year. If the scores in a subdivision for a given year are below the National mean score in a particular subject area then we have discussed changes to be made to improve the scores in that given area. We have made changes to the overall curriculum in some cases and have made changes to courses pertaining to that subdivision in other cases. Below we have provided a table of the comparisons between raw CSU institutional scores in those 4 different subdivisions and the mean raw institutional scores for all college/universities taking the tests.

CSU mean higher than National mean
CSU mean same as National mean
CSU mean lower than National mean

BIOLOGY		CSU	National	CSU	National	CSU	National	CSU	National	CSU	National	CSU	National	CSU	National
Year		Spring 2003		Spring 2004		Spring 2005		Spring 2006		Spring 2007		Spring 2008		Spring 2009	
Number taking test (students for CSU; institutions for National data)		8	319	9	342	13	342	26	342	16	255	32.0	381.0	20	381
Institutional mean score		153.2	153.4	155.3	153.2	159.7	153.2	154.6	153.2	162.0	152.4	152.3	152.2	153.9	152.2
Subscore	Subdivision														
S1	Cell Biology	58.9	55.4	60.3	55.2	69.7	55.2	58.1	55.2	62.3	52.9	54.8	52.8	54.5	52.8
S2	Molecular Biology and Genetics	53.9	54.7	61.4	54.6	59.3	54.6	55.7	54.6	62.3	52.7	51.5	52.7	54.3	52.7
S3	Organismal Biology	55.1	52.3	52.0	52.0	55.8	52.0	55.7	52.0	61.3	52.6	51.6	52.5	51.6	52.5
S4	Population Biology, Evolution and Ecology	49.5	53.0	49.8	52.8	52.8	52.8	49.4	52.8	58.5	52.1	52.2	51.9	55.1	51.9

During 2003 we noted that our overall institutional score was lower than the National average, however, the overall institutional mean score was above the National average in all subsequent years. Students taking the exam in 2003 were not required to take a courses devoted to Plant Biology, Evolution & Population Genetics or Ecology Laboratory. It is likely that this caused problems. Since S4 (Population Biology, Evolution and Ecology) and S2 (Organismal Biology—including plants) were also below the national average in 2003. The Biology assessment and curriculum committee initiated changes in the biology curriculum as a result of these initial scores. This is summarized below.

S4 remained low in 2004, 2005 and 2006. This lead to concern since the topics population biology and evolution were covered mostly in our Principles of Biology sequence (BIOL 1107/L and BIOL 1108/L), but were not covered in great detail in the upper division courses. Prior to 2006 we did not offer an Ecology laboratory or and Evolution and Population Genetics course. We made both of these courses requirements in the Biology curriculum starting in the Fall 2005 (for Ecology laboratory) and Spring 2006 (for Evolution and Population Genetics). Students taking the exam during Spring 2007, 2008 and 2009 scored above the national average in area S4 (Population Biology, Evolution and Ecology). It appears that adding these courses has improved this area.

S2 (Organismal Biology) improved in 2004 after a Plant Biology course was added to the curriculum as a required course for all Biology majors. Additionally, an Animal Physiology course was added to the curriculum as a required course starting in the Fall of 2005. An improvement in this area was noted in 2005, 2006 and 2007, but a decline was also noted in this area in 2008 and 2009. The CSU raw scores for plant biology are significantly lower than animal biology in 2008 (Animal=60, Plant = 40) and 2009 (Animal=57, Plant=41). The Biology curriculum committee is considering some changes to the Biology curriculum. We are considering making Plant Biology a required upper division 3 credit course, since it is currently a 2000 level 2 credit course). One of the challenges of doing this would be that we would have to remove another upper division biology course from the curriculum to make room for this course. There is disagreement on which course should be removed since most of the Biology majors in our program are interested in pursuing degrees in medicine and cell/molecular biology and have no interest in Plant Biology. We recognize that our graduates from Biology have weak content knowledge in the area of Plant Biology, but we also feel that that it may not actually prevent them from pursuing their career goals. During the Spring of 2003 and Spring of 2008 students scored below the national average in S2 (Molecular Biology and Genetics). We do not see a general trend in this area. We have not considered changes in the curriculum to address this area.

Indirect Assessment

Learning Outcome 1 is also assessed indirectly using an Exit Interview that is given to all Biology majors the semester that they graduate and an alumni survey. During the exit interview the students are asked, "How would you rate the Biology degree program in preparing your knowledge of the Major Fields of Biology."? Since 2003 the students always rate our program very high in this area and we have noted no deficiencies. We have not collected much data for the alumni survey, but we are in the process of tweaking it to produce an online survey that is easier to complete. What we have collected, however, is data on what our students are currently doing after graduation. We have created a database of up-to-date email addresses and sent out annual emails asking students to provide us with updates on their career successes. From this data we are able to say that we know that 27% of all of our graduates since 2001 that we have been able to track (n=166) were accepted into graduate or professional programs related to Biology after graduation. We also know that 10% of our graduates are working in a field related to biology. It has been a struggle to track our alumni. We are working on a better system of collecting data from our alumni.

Learning Outcome 2

Direct Assessment

Learning Outcome 2 is measured by using laboratory skills tests to assess the student's ability to perform certain laboratory skills. The various instructors design the skills tests. The students perform them in the lab and the instructor uses a rubric to score their performance. The individual instructors have designed the rubrics. The scores on these exams count toward the student's final grade in that class. The Biology Curriculum Committee determined which skills should be and could be assessed. The skills include the following:

- Animal dissections
- Microbiology laboratory skills (streak plating, aseptic technique, microscopy, slide/smear preparation, bacterial staining)
- Molecular biology laboratory skills (use of pipette device, use of centrifuge, using primers for PCR, running a DNA agarose gel)
- Chemistry Skills as related to Biology labs
- Ecology laboratory skills.

Microbiology Lab Skills

The microbiology laboratory skills were assessed each Fall and Spring semester since Spring 2006 (except Spring 2008). Prior to Fall 2006 we simply had a collective grade for all 5 skills as we neglected to save specific copies of the rubric before they were returned to the students. Starting in Fall 2009 we have the specific assessment for each skill. The data below shows student success in the microbiology laboratory skills. Students who exceed expectations are those who score 18, 19 or 20 points out of 20 ("A"). Students who meet expectations are those who score 16 or 17 out of 20 ("B"). Students who do not meet expectations score below a 16 ("C" or below).

Table 1. Microbiology Laboratory Skills Assessment (numbers indicate ratio of students in each category).

	SP06 (n=44)	FA 06 (n=23)	SP 07 (n=22)	FA 07 (n=24)	FA 08 (n=22)	SP09 (n=22)	FA09 (n=24)	**Average (n=181)**
Exceeds Expectations	0.341	0.565	0.545	0.458	0.50	0.429	0.458	0.471
Meets Expectations	0.409	0.261	0.364	0.417	0.273	0.238	0.542	0.357
Does not Meet Expectations	0.250	0.174	0.091	0.125	0.227	0.333	0.00	0.171

SP=Spring, FA=Fall

According to our assessment it seems that on average 17.1% of the students do not meet expectations on the microbiology laboratory skills. Please note that we expect the students to score a 16 or above (B or better). This expectation may appear too lofty and we may consider lowering it to a score of a 15 (high C or better) in the future. The average percentage of students scoring below the C range is actually 5.6%. Currently, we are not concerned about our ability to teach microbiology laboratory skills since greater than 80% of our majors are meeting or exceeding expectations.

Molecular Biology Lab Skills

We have assessment data for the molecular biology laboratory skills from the Spring 2009 semester. Prior to this semester we did not maintain the assessment data for these skills as they were returned to the students. The students are assessed in BIOL 4202L (Biotechnology Lab). The data below shows student success in the molecular biology laboratory skills. Students were asked to perform simple tasks related to a molecular biology lab and were scored as "meets expectations" if they could perform the task or "doesn't meet expectations" if they could not perform the task.

Table 2. Molecular Biology Laboratory Skills Assessment for Spring 2009 (numbers indicate ratio of students in each category).

Skill (n=23)	**Meets Expectations**
Reading P2 Pipette	1
Reading P20 pipette	0.957
Reading P100 Pipette	0.957
Reading P1000 Pipette	0.957
Reading 10ml pipette	0.522
Selecting correct pipette aid for lab application	0.696
Balancing a centrifuge	0.957
Identifying correct annealing temperature and time for PCR	0.957
Setting up and loading a DNA agarose gel	1

This data show two areas of concern: Reading a 10 ml pipette and selecting the correct pipette for a particular laboratory application. The instructors in the biotechnology class are in the process of making videos that they can post on the web to assist students with learning the biotechnology laboratory skills. They have already created some videos concerning gel electrophoresis and are in the process of creating other videos. The Biology Curriculum Committee will discuss the use of videos to assist students with the two skills that many students were not able to achieve.

Animal Dissection Lab Skills

Animal dissections are performed in two classes that are required of all biology majors: BIOL1108L, Principles of Biology II lab (which dissects several invertebrates as well as fetal pigs, sheep eyes, sheep brains, and sheep hearts) and BIOL3650L Comparative Vertebrate Anatomy (which dissects sharks, mudpuppies, cats, sheep eyes, sheep brains, and sheep hearts). Assessment of animal dissections began in BIOL3650L in the Fall of 2008 and was repeated in the fall of 2009. Prior to these semesters, we did not collect assessment data on dissections – they were qualitatively observed by the instructor, but it became clear that it would be necessary to grade the dissections to ensure that students were working well on the dissections. In this class students must work in groups due to the costs of the specimens and the time constraints of the lab, because it is not possible for an individual student to complete the dissections during the time available in lab. Each group member receives the same score for the dissections. Dissections are graded in three categories: quality of dissections, completeness of dissections, and completing the dissections on time. Each category is graded on a scale from 0 to 4. Because the work is done in groups, scores tend to be fairly high, so the criterion for exceeding expectations is 3.8 out of 4, meeting expectations is 3.2 out of 4 and anything below that is failing to meet expectations. In 2008 with 43 students in two lab sections, 41 exceeded expectations while 2 met them. In 2009 with 19 students 17 students exceeded expectations, while two students failed to meet expectations. In this case, both students had one unexcused absence from lab, meaning that they had a zero for the dissection done on the day they were absent. If only the labs for which they were present are counted, then those two students also exceeded expectations.

Ecology Lab Skills

We currently do not have any data available to assess the skills associated with ecology. Assessment of ecology lab skills will occur during the spring 2010 semester and data will be analyzed.

Chemistry Lab Skills

The Biology Curriculum Committee decided in 2009 that it was important to assess some chemistry laboratory skills. Presented below are data for some of these chemistry lab skills from Spring 2009 through Fall 2009. Students were asked to perform simple tasks in the chemistry lab and were scored as "meets expectations" if they could perform the task or "doesn't meet expectations" if they could not perform the task.

Table 3. Chemistry Laboratory Skills Assessment for 2009 (numbers indicate ratio of students in each category).

	Spring 2009 (n=16)	**Summer 2009 (n=7)**	**Fall 2009 (n=10)**
Skill	**Meets**	**Meets**	**Meets**

	Expectations	Expectations	Expectations
Determine density of solution	0.750	1.00	0.700
Set up Buchner filtration apparatus	0.688	0.714	0.700
Recrystallize an unknown compound	NA	NA	0.700
Determine melting point of unknown compound	NA	NA	0.700
Collect and analyze FTIR data	NA	NA	0.700

At this point we do not feel the need to make any curriculum changes in the chemistry labs as it seems that the majority of the students are able to meet expectations on these particular laboratory skills. We have plans for assessing other skills in chemistry starting in the Spring of 2010.

Computer Technology Skills

For computer technology skills related to biology (i.e. sequence analysis) student skills were assessed in BIOL 4900 during the Spring semester of 2009. Students were assessed using questions on the final exam that covered the use of a variety of tools. The exam was worth 120 points, but 76 of those points were direct applications of technology (where students had to use the software or websites directly to answer the question). The questions covered a variety of topics that had been covered throughout the semester. We classified a student as exceeding expectations with 80% or more of the 76 points. Meeting expectations required the student obtain 70-80% of the points, while failing expectations would be those who earned fewer than 70% of the points.

Table 4: Spring 2009 Computer/Technology Skills assessment data (n=24) (Refers to computer and technology skills directly related to Biology)

Proportion of students who exceeded expectations	0.375
Proportion of students who met expectations	0.25
Proportion of students who did not meet expectations	0.29

We are not satisfied with the results of this assessment. We feel that we can change the course curriculum to fix the problem. Currently, the majority of the computer/technology assignments are completed as homework and students were working in groups. One or two students will end up carrying the group and we end up with several students who neglect to learn the technology and

computer skills. We plan to change the curriculum to provide more class time to work on assignments that require the students to use their computer and technology skills. All students will be required to work independently and it is expected that a greater percentage of students will pass the technology/computer skills assessment on the final exam.

Indirect Assessment

All Laboratory and Technology Skills

Learning Outcome 2 is also assessed indirectly using an Exit Interview, Laboratory Skills and Computer/Technology Skills Surveys that are given to all Biology majors the semester that they graduate. During the exit interview the students are asked, "How would you rate the Biology degree program in preparing your mastery of a broad range of basic lab and computer skills applicable to biology?" The laboratory skills survey consists of 69 questions about various laboratory skills we think our students should be able to demonstrate. It is inherently difficult to directly assess all of these skills in the laboratory. There is a general expectation that if a student passes the laboratory course then he or she has managed to learn most of the skills. Students who are unable to pass all of the required labs are not allowed to graduate. However, we are able to assess some of the laboratory skills directly (see above). For those skills that we are unable to assess directly we rely on the results of the exit interview and survey to help us determine if we need to make changes in the laboratory.

The results from the exit interview since 2003 indicate that the students typically rate our program very high in the area of preparing their mastery of basic laboratory and computer skills we have noted only two deficiencies as reported by the Exit Interview. Prior to spring of 2003 students were not required to take Comparative Vertebrate Anatomy and Biotechnology. Students were given the option to choose between these two courses and take either CVA lecture and lab or Biotechnology lab. Additionally, the lab contact hours for both courses were 2 hours. There was not enough time in each laboratory for the students to master the material and most of the students interviewed prior to a curriculum change made in 2003 indicated that they felt they had deficiencies in biotechnology, animal dissections, and animal form and function. The curriculum was changed in the Spring of 2003 such that CVA lecture (3 contact hours), CVA lab (3 contact hours) and Biotechnology lab (6 hours) were required for all graduates of biology degree program. The increased laboratory time and the requirement for these courses helped tremendously. Students interviewed after the curriculum change indicated that they could master the skills applicable to these courses.

The Laboratory Skills and Computer/Technology Skills Surveys have been monitored closely since 2003. A copy of this survey is attached. In this survey the students rate our program on a scale of 1-5 on their mastery of various laboratory skills. An average score below 4 for a given skill indicates a concern to us. We have addressed some areas of concern and the table below indicates the perceived problem with a particular lab skill and what we have done (or will do to address the problem). We have revised the

Lab Skills Survey and the Computer Skills Survey in the Fall of 2009 to better reflect what we teach in the laboratory and to clarify some of the questions for the students. New questions were added and some were deleted.

Table 5: Lab survey questions that were addressed due to low scores.

Survey Question	**Perceived Problem**	**Explanation and how we addressed the problem.**
17 I am able to apply basic statistics (Chi Square test for example) to test for significant differences between treatment groups.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	The wording of the question is confusing. We teach various statistical methods and Chi Square is only one. Chi Square is typically taught in lower division biology courses. Students transferring in, may have not had these courses with us, thus do not have a mastery of Chi Square. We expanded the definition of basic statistics (updated Fall 2009) and have recommended that faculty who have students use Chi Square in upper division courses offer a review to the transfer students.
26 I am able to control microbial growth in clinical and laboratory settings.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	We changed the wording and updated the survey in the Fall of 2009. Students were confused by the term clinical settings since our labs are not clinical settings.
30 I am able to perform basic total RNA isolation.	Faculty members teach Biotechnology lab differently and only some do RNA techniques. RNA isolation is rarely taught and most faculty do not feel this is an essential skill.	We removed this question since RNA isolations are rarely done in Biotechnology and since RNA isolation is not an essential skill for a biology major.
31 I am able to perform basic protein isolations.	Score was low prior to 2007 because we did not have the equipment to do protein	We purchased enough equipment to support the teaching of this skill and the score improved dramatically.

	detection.	
33 I am able to perform Western blot analysis of proteins.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	Faculty members teach Biotechnology lab inconsistently. There is now agreement that this technique is pretty essential so we are teaching is more consistently.
36 I am able to construct oligonucleotide primers for PCR.	Scores in this area are consistently low. We don't teach how to actually construct primers, but we do teach how to use primers and calculate annealing temperature.	We changed the wording of this question to reflect what we actually teach (updated in Fall 2009).
38 I am able to use marker genes for transformation efficiency.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	We changed the wording of this question to better reflect what we actually teach.
42 I am able to write abstracts for scientific meetings.	We don't actually teach this anymore.	We removed this question from the survey.
53 I am able to execute decanting.	Scores in this area are frequently low.	We addressed this issue by changing the curriculum in chemistry lab courses so that students better understand the concept of decanting.
54 I am able to execute synthesis of a chemical compound.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	Several laboratory experiments in the Principles of Chemistry and Organic Chemistry laboratory courses involve chemical synthesis. Scores in this area are likely to fluctuate with student confidence in chemical techniques. Additional questions have been added to the survey in an attempt to identify specific skills students do not feel confident with.

59 I am able to perform a fractional distillation to purify an organic compound.	Recent scores in this area tend to be low.	We addressed this issue by changing the curriculum so that two laboratory procedures in the first organic chemistry course now involve distillation.
60 I am able to heat a reaction mixture at a reflux state for thirty minutes.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	We addressed this issue by changing the curriculum in chemistry lab courses so that students better understand the concept of reflux.
62 I am able to collect FTIR spectral data.	Recent scores in this area tend to be low.	More emphasis is being placed on collection and interpretation of FTIR data. FTIR is used in at least five laboratory procedures in the organic chemistry laboratory sequence.
63 I am able to analyze FTIR spectral data.	Recent scores in this area tend to be low.	More emphasis is being placed on collection and interpretation of FTIR data. FTIR is used in at least five laboratory procedures in the organic chemistry laboratory sequence.
64 I am able to analyze mass spectrometer data.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	We have had some trouble with our mass spectrometer, but the problem has been fixed. We expect an overall improvement.
65 I am able to analyze ^{1}H-NMR and ^{13}C-NMR data.	Scores in this area are inconsistent from semester to semester. Sometimes we score high and other times we score below a 4.0.	We currently don't have an NMR, but we provide students with the data to analyze. We hope to purchase an NMR and focus on this area in the near future.

Table 6: Computer/Technology survey questions that were addressed due to low scores.

Survey Question	**Perceived Problem**	**Explanation and how we addressed the problem.**
9. I am able to design a web page using appropriate software.	Recent scores in this area tend to be low.	The Natural Sciences faculty decided that they don't have time to teach this don't feel it is a skill that should be necessarily taught in the science courses. We have removed this from the

		computer skills assessment form.
11. I am able to upload files to personal Web space.	Recent scores in this area tend to be low.	The Natural Sciences faculty decided that they don't have time to teach this don't feel it is a skill that should be necessarily taught in the science courses. We have removed this from the computer skills assessment form.
17. I am able to use 3D graphics software, such as Protein Explorer, to analyze protein structure.	Scores in this area are consistently low.	We are going to require the assignments in BIOL 4900 (all computer and technology based assignments) to be completed in class rather than completed as homework. Students have a tendency to work in groups on homework assignments so some students don't learn the skills. This weakness was observed in our formal assessment as well.
18. I am able to use data acquisition software, such as Science Workshop, to collect and process experimental data.	Scores in this area are consistently low.	Students do not understand the meaning of this question because we use the terms "Science Workshop" as the example. We don't actually use data acquisition software called "Science Workshop." We use something else. So we modified the question to more accurately describe the software.

Learning Outcome 3

Direct Assessment

Learning Outcome 3 is measured by using embedded exam questions in select classes. We have used it to assess student's knowledge during the Spring 2009 semester in BIOL 1108L (Principles of Biology II Lab) and BIOL 1107L (Principles of Biology I) and the Fall 2009 semester in BIOL 3250 (Microbiology) and BIOL 3380 (Evolution and Population Genetics). BIOL 1107L and 1108L have a math requirement (entrance into MATH 1111—College Algebra), but do not have a statistics requirement. Students are taught the statistics necessary during a lecture component within these two courses. Students typically take BIOL 3380 after they have completed MATH 1111 and MATH 1231 (Statistics), but it is not a requirement. Students are required to take MATH 1111 and MATH 1112A (College Algebra and Trigonometry & Analytical Geometry) and most take MATH 1231 (not a requirement) before they take BIOL 3250.

In each of these courses, students were asked a question on an exam that required them to use math and/or statistics skills and they were scored using a point value for that question. Students who exceeded expectations provided answers that were superior

(received full points). Students that met expectations provided answers that were good (received most of the points). Students who did not meet expectations provided answers that were either wrong or did not explain the concept well enough to receive most of the points. We plan to assess this outcome more often in the future, but currently do not have the data for subsequent semesters. The results from these assessments are discussed below.

Table 1: Embedded exam question concepts and results

Course/Semester	Question addressed…	Ratio of students exceeding expectations.	Ratio of students meeting expectations.	Ratio of students not meeting expectations.
BIOL 1108L/Spring 2009	Student T-test and Chi Square test (n = 45)	0.15	0.22	0.63
BIOL 1107L/Spring 2009	Chi Square Test (n=91)	0.50	0.00	0.50
BIOL 3380/Fall 2009	Application of algebra skills to questions in evolution and population genetics (n=38)	0.56	0.04	0.40
BIOL 3250/Fall 2009	Application of algebra skills to questions in microbiology (n=39)	NA (multiple choice exam)	0.95	0.05
BIOL 3250/Fall 2009	Application of chemistry skills to questions in microbiology (n=39(	NA (multiple choice exam)	0.46	0.54

Pertaining to math and statistics

BIOL 3250 showed a higher success rate than the others in mathematics. There is a specific math requirement before students are permitted to take BIOL 3250. There is not a specific math requirement before students are permitted to take BIOL 1107, 1108 and 3380. We may consider looking more closely at the students and compare the students who have completed MATH 1111 and MATH 1112A and MATH 1231 with those who have not completed these courses to see if the MATH courses help to increase student

success on these embedded exam questions. If we do see a greater ability to answer these embedded questions in those who have taken these math courses then we may consider changing the prerequisites for these courses to include more mathematics preparation. If we do not see a greater success then we will consider offering more assistance (supplemental instruction) with topics in biology pertaining to mathematics and statistics.

Pertaining to chemistry and physics

BIOL 3250 showed a marginal success rate in the application of chemistry to microbiology. More data will be collected to determine if curriculum changes should be made or if this data set was an anomaly.

Indirect Assessment

Students are asked during their exit interview if we have prepared them well in mathematics, statistics, chemistry and physics. All students answer this question very positively when it related to chemistry and physics, however most students state that our mathematics and statistics courses do not prepare them well for the biology material related to math and statistics. We have recognized that we need to concentrate on making a change in this area to improve our students' preparation in the application of mathematics and statistics to biology.

Learning Outcome 4

Direct Assessment

Learning Outcome 4 is measured using standardized rubrics developed by the Natural Sciences faculty. We developed a rubric for scoring oral presentations (using Power Point) and a rubric for writing scoring writing ability. The results of assessment in various classes during various semesters are below.

Oral Presentation Skills

Data was collected from BIOL 4900 (Biocomputing) during Fall 2006 and Spring 2008 and BIOL 4222 (Biology Research Practicum) during Spring 2009.

Table 1: Fall 2006 Oral Skills Assessment Data from BIOL 4999 (n=22)

Criteria	Ratio of students scoring 2.8 or above (exceeds expectations)	Ratio of students scoring 1.8 to a 2.7 (meets expectations)	Ratio of students scoring below a 1.8 (does not meet expectations)
Organization	0.73	0.27	0.00

Subject Knowledge	0.54	0.41	0.05
Graphics and Data	0.59	0.36	0.05
Mechanics	0.82	0.18	0.00
Presentation Style	0.27	0.73	0.00
Timeliness	0.68	0.27	0.05

Table 2: Spring 2008 Oral Skills Assessment Data from BIOL 4999 (n=25)

Criteria	Ratio of students scoring 2.8 or above (exceeds expectations)	Ratio of students scoring 1.8 to a 2.7 (meets expectations)	Ratio of students scoring below a 1.8 (does not meet expectations)
Organization	0.80	0.12	0.08
Subject Knowledge	0.32	0.56	0.12
Graphics and Data	0.44	0.56	0.00
Mechanics	0.48	0.48	0.04
Presentation Style	0.12	0.80	0.08
Timeliness	0.80	0.20	0.00

Table 3: Spring 2009 Oral Skills Assessment Data from BIOL 4222 (n=10)

Criteria	Ratio of students scoring 2.8 or above (exceeds expectations)	Ratio of students scoring 1.8 to a 2.7 (meets expectations)	Ratio of students scoring below a 1.8 (does not meet expectations)
Organization	1.00	0.00	0.00
Subject Knowledge	0.80	0.20	0.00
Graphics and Data	1.00	0.00	0.00
Mechanics	0.90	0.10	0.00
Presentation Style	0.60	0.40	0.00
Timeliness	1.00	0.00	0.00

Oral presentations in these two courses have been required since 2001 when the program began. We do not feel that there is any need to make changes in the Biology curriculum to improve this area. The majority of our students appear to be meeting our expectations on the ability to communicate their knowledge orally. Students take a communications course during their freshman

or sophomore year. We also cover the essentials of making a scientific presentation using Power Point in BIOL 4900. There are other courses found in the Biology Core that require oral presentations as well.

Written Communication Skills

Data was collected from BIOL 3380 (Evolution and Population Genetics) during Spring 2009, BIOL 4202L (Biotechnology) during Spring 2009 and BIOL 4450 (Immunology) during Fall 2009. We don't have any data to present previous to Spring 2009 as the written assessments were returned to the students. Individual faculty members scored the written assessment.

Table 4: Spring 2009 Written Skills Assessment Data

	Ratio of students exceeding expectations	Ratio of students meeting expectations	Ratio of students not meeting expectations
BIOL 3380 (n=34)	0.44	0.32	0.24
BIOL 4202L (n=23)	0.39	0.57	0.04

Table 5: Fall 2009 Written Skills Assessment Data

	Ratio of students exceeding expectations	Ratio of students meeting expectations	Ratio of students not meeting expectations
BIOL 4450 (n=11)	0.55	0.45	0

Most students met expectations in each of the 3 courses. Research papers in these courses have been required since they were first offered. Other courses in the Biology core also require the students to write research papers. We do not feel that there is any need to make changes in our curriculum to improve this area. The majority of our students appear to be meeting our expectations on the ability to communicate their knowledge in writing. Since this is a small dataset, we will continue to collect data in this area and make improvements if necessary.

Indirect Assessment

Students are asked during their exit interview how our program has prepared their oral and written communication skills. The vast majority has only positive things to say. Most of the students explain that they hate public speaking, but recognize the importance of that skill. They frequently say that they really despise having to make oral presentations, but feel that they have improved tremendously over time and have had ample opportunity to practice these skills throughout their time at CSU. Some students have indicated that they wished they had more instruction on plagiarism (how to avoid it for example). Some indicated that they wished they had more early assistance with their writing skills. The university has opened a Writing Center recently. Faculty members are advertising this more often in their courses and we hope that more students will be motivated to obtain assistance with their writing skills from the Writing Center.

Learning Outcome 5

Direct Assessment

Learning Outcome 5 is measured in a variety of ways. We measure it based on student performance on analyzing data in laboratory reports. We measure it using the ETS Major Fields Test (MFT) in Biology --Analytical section. We also measure it using some embedded questions on exams that require analytical skills. The results from these assessments are discussed below.

Analytical Skills Measured by Assessing Student Performance on Laboratory Reports

Data was collected from BIOL 3250L (Microbiology Lab) during Spring 2009, BIOL 1107L (Principles of Biology Lab) during Fall 2009 and BIOL 1108L (Principles of Biology II Lab) during Spring 2009. Laboratory reports are graded using a rubric developed by the Natural Sciences Faculty.

Table 1: Spring 2009 Analytical Skills Assessment (Laboratory Reports)

Course	Ratio of students exceeding expectations.	Ratio of students meeting expectations.	Ratio of students not meeting expectations.
BIOL 3250L	0.05	0.75	0.20
BIOL 1108L	0.48	0.25	0.27

Table 2: Fall 2009 Analytical Skills Assessment (Laboratory Reports)

Course	Ratio of students	Ratio of students	Ratio of students not

	exceeding expectations.	meeting expectations.	meeting expectations.
BIOL 1107	0.54	0.33	0.13

We are concerned mostly about our student's performance in the upper division course, BIOL 3250L. Juniors take this course. Students have experienced analyzing data and writing laboratory reports in at least 6 labs prior to taking this course. We expected our ratio of students meeting or exceeding expectations to be at least 90%, but instead 80% of our students are meeting or exceeding expectations.

Analytical Skills Measured by the ETS Biology Major Fields Test (Analytical Section)

All Biology majors are required to take the ETS MFT in Biology the Semester that they graduate. One of the assessment indicators on this test is an Analytical section. We have included our assessment data below, which compares the mean of our students in various semesters to the national mean. The scores highlighted in yellow indicate years in which our students scored below the national average.

Table 3: Performance on the Analytical Section of the ETS-MFT Biology

Year	Raw score for mean	CSU mean
2003	50.0	52.5
2004	50.0	45.1
2005	50.0	49.5
2006	54.0	51.2
2007	53.5	61.0
2007	54.0	48.0
2008	54.0	53.0

The assessment data pertaining to analytical skills is a concern to the faculty members in the Department of Natural Sciences. We recognize that this is a weak area for our students. We recognize that the analytical and math skills of our freshman students are below average when they enter our program (anecdotal observations and observations of the math placement data for all CSU freshman). Their skills do not appear to be improving over time.

To address the low values on analytical assessments given during the junior and senior year, we are trying to incorporate more assignments that require application of math skills (force students to seek assistance in our center for academic success for their math skills), data interpretation, data analysis and experimental design in our courses. In addition to incorporating more assignments to improve skills, we are also planning to assess analytical skills more often using embedded questions on exams in upper division courses throughout our curriculum.

Analytical Skills Measured by Assessing Student Performance on an embedded exam question

Data was collected from BIOL 3250L (Microbiology) during Fall 2009. In an attempt to include more analytical assignments and assessments in class this was a trial on using embedded exam questions after teaching students how to attempt problems that require analytical skills in class. During this assessment students were asked to interpret data on a graph pertaining to a specific experiment. We found that 0.821 students met expectations. Throughout that semester students were given several assignments prior to the assessment exam that required them to interpret data pertaining to a specific experiment. We feel that if we were to include more assignments and assessments on analytical skills in a greater number of our required classes that this could help to improve the student's analytical performance on the Major Fields Test. We will attempt to do this over the next few years.

Learning Outcome 6

Direct Assessment

Learning Outcome 6 is measured using standardized rubrics developed by the Natural Sciences faculty. We developed a rubric for scoring collaborative work where 2 or more students must work together on a project. Data was collected from BIOL 4900 (Biocomputing) during Fall 2006, Spring 2008 and Fall 2009 and BIOL 3380 (Evolution and Population Genetics) during Spring 2009.

Table 1: Fall 2006 Collaborative Work Assessment Data from BIOL 4900 (n=17)

Criteria	Ratio of students scoring 2.9 or above (exceeds expectations)	Ratio of students scoring 2.1 to a 2.8 (meets expectations)	Ratio of students scoring below a 2.1 (does not meet expectations)
Assuming a role in the project	0.88	0.12	0.00
Respect for other group members	0.94	0.06	0.00

Responsibility	0.65	0.29	0.06
Contribution	0.65	0.29	0.06

Table 2: Spring 2008 Collaborative Work Assessment Data from BIOL 4900 (n=22)

Criteria	Ratio of students scoring 2.9 or above (exceeds expectations)	Ratio of students scoring 2.1 to a 2.8 (meets expectations)	Ratio of students scoring below a 2.1 (does not meet expectations)
Assuming a role in the project	0.86	0.09	0.05
Respect for other group members	0.86	0.14	0.00
Responsibility	0.81	0.05	0.14
Contribution	0.86	0.05	0.09

Table 3: Fall 2009 Collaborative Work Assessment Data from BIOL 4900 (n=24)

Criteria	Ratio of students scoring 2.9 or above (exceeds expectations)	Ratio of students scoring 2.1 to a 2.8 (meets expectations)	Ratio of students scoring below a 2.1 (does not meet expectations)
Assuming a Role	0.67	0.29	0.04
Respect	0.79	0.21	0
Responsibility	0.58	0.33	0.08
Contribution	0.67	0.25	0.08

Table 4: Spring 2009 Skills assessment data from BIOL 3380 (n=38)

Criteria	Ratio of students scoring 2.5 or above	Ratio of students scoring 1.8 to a 2.5	Ratio of students scoring below a 1.8
Worked well	0.89	0.11	0
Work on time		0.16	0.03

	0.82		
Took part	0.87	0.11	0.03
Did tasks	0.47	0.26	0.26

Many of the courses in the Biology core require collaborative work by the students. BIOL 4900 and BIOL 3380 have always required group work. Students in our program have to work together on many projects. The courses above show assessment data from courses taken in the junior and senior year. It seems that the majority of our students meet our expectations for collaborative group work and quite a few actually exceed our expectations. We do not feel the need to make any curriculum changes based on our data.

Indirect Assessment

All Biology majors are given an exit interview. During this exit interview students are asked how we prepared them to work collaboratively on group projects. The majority of the students explain that they do not like doing group work, but they recognize the importance of being able to work cooperatively with others. Almost all students interviewed feel that they receive ample opportunity to do group projects and practice these skills.

Learning Outcome 7

Direct Assessment

Learning Outcome 7 was dramatically changed during the Fall semester of 2008. Previously this outcome was impossible to assess. The previous outcome was written as such: Students will gain an appreciation for the impact of Biology on the environment and on society. We realized this too late to collect enough data to assess is properly. The current outcome as written can be assessed more easily.

Learning Outcome 7 is measured by using embedded exam questions in select classes. We have used it to assess student's knowledge during the Fall 2009 semester in BIOL 3250 (Microbiology) and during the summer 2009 semester in BIOL 3550. Students were asked a question pertaining to the impact of the biology on the environment and society and they were scored using a point value for that question. Students who exceeded expectations provided answers that were superior (received full points). Students that met expectations provided answers that were good (received most of the points). Students who did not meet expectations provided answers that were either wrong or did not explain the concept well enough to receive most of the points. We plan to

assess this outcome more often in the future, but currently do not have the data for subsequent semesters. The results from these assessments are discussed below.

Table 1: Results from embedded exam questions

Course/Semester	Question	Ratio of students exceeding expectations.	Ratio of students meeting expectations.	Ratio of students not meeting expectations.
BIOL 3550/Summer 2009	Why are corals particularly susceptible to global warming? (n = 5)	0.40	0.40	0.20
BIOL 3550/Summer 2009	What are some factors contributing to the diversity of life on an island? (n = 2)	0.50	0.00	0.50
BIOL 3550/Summer 2009	Discuss the theory of island biogeography. Who developed it? What are its components? How has it been tested? Did the data support it? (n = 6)	0.80	0.00	0.20
BIOL 3550/Summer 2009	Discuss the island subsidence theory. Who developed it? How has it affected coral reefs in the Indo-pacific? In the Atlantic? (n = 4)	0.80	0.00	0.30
BIOL 3250/Fall 2009	Explain one impact the field of Microbiology has had on one of the following industries: Food, Medical, Pharmaceutical, and Transportation. (n=38)	0.26	0.61	0.13

It is evident that more data is necessary before we make any decisions concerning this outcome. The sample size for BIOL 3550 was not high enough for Summer 2009. We collected data from only one other class, which indicates satisfactory progress in this area with a sample size of 39. We have plans for continued assessment of this outcome in the future.

Indirect Assessment

Students are asked during their exit interview if they have gained an understanding of how biology has impacted the environment and society. All students answer this question very positively and many have provided some nice examples during the interview.

Conclusions Regarding Discussion of Results and Changes for All Seven Learning Outcomes

Here is a bulleted Summary of our future directions regarding the assessment of our seven outcomes.

Outcome 1

- We may make changes in the curriculum to include more plant biology. We are discussing this change currently, but are also considering the impact on our strength in other fields of biology. Increasing the plant biology content will mean reducing content in another area. Since most of our biology majors pursue career goals that are not related to plant biology we feel it may not be necessary to increase our plant biology content area. Alternatively, we may try to increase the amount of topics related to plant biology in other existing courses in the curriculum.
- We will continue to monitor our other content areas using the Biology Fields test to make sure there are no other patterns of decline.
- We will develop a better system for collecting data from our alumni to assure that we are preparing them for successful careers in biology related jobs.

Outcome 2

- We will continue to monitor our laboratory skills in molecular biology, microbiology, animal dissections, ecology, chemistry, and computer technology. Due to our lack of data and/or problems with ecology, molecular biology and computer technology, we will focus our attention in these areas over the next couple of years.
- We will create videos that we can post online to instruct students how to select the correct pipette for various laboratory applications and to instruct students how to use pipettes that transfer solutions greater than 1ml (i.e. 10 ml pipettes).

- We will provide more "in class" time to learn and practice computer technology skills related to biology in the BIOL 4900 course (Biocomputing).
- We will provide more assistance with statistical methods that we require students to use in our laboratory courses.
- We will start using updated versions of our Laboratory Skills and Computer Skills surveys to better assess what we teach in our courses.

Outcome 3

- We will gather more data to monitor our success with student's ability to apply their math, statistics, physics and chemistry knowledge to biology. We feel that we have not collected enough data here to draw enough conclusions.
- We will consider placing a high math requirement in our lower division biology courses so that students will be better able to apply their knowledge of math to biology.

Outcome 4

- We will continue to collect data and monitor this area. We will concentrate on writing skills assessment data since we have less data for writing skills than we have for oral presentation skills.

Outcome 5

- We will continue to monitor this area and look very closely at our curriculum to investigate ways in which we can improve this area.
- We will incorporate more assignments that require application of math skills, data interpretation, data analysis and experimental design in our courses.

Outcome 6

- Due to our need to monitor other areas more closely we will monitor this outcome less closely in the future since it appears that our students are meeting and exceeding expectations in this area.

Outcome 7

- The faculty in Natural Sciences feel that this outcome is less important to a biology major and much more difficult to assess than other outcomes. We need to collect more data on this outcome before we can make plans for any major curriculum changes. We may consider deleting this outcome so that we can focus on our other areas for improvement.