Science General Education Annual Assessment Report 2012-2013

I. Introduction

The Science General Education Program serves all Oregon Tech degree students, who are each required to complete 12 science credits selected by the student or specified by the major department.

II. Program Purpose, Objectives and Student Learning Outcomes

The faculty in the Natural Science Department who are part of the Science General Education Program met in September 2012 to review the Science General Education program purpose, objectives, and student learning outcomes. The faculty affirmed them without changes.

Science General Education Program Purpose

To provide lower division science courses appropriate for science, technology, engineering, health, and liberal arts students.

Program Educational Objectives

1. Understanding of fundamental scientific principles or concepts.
2. The ability to apply fundamental principles or concepts to solve problems.

Student Learning Outcomes

The student learning outcomes and performance criteria for the Science General Education program are as follows:

SLO 1: Students will demonstrate scientific knowledge and skills in scientific reasoning.

Criteria for Assessment: Students will be able to

1. Demonstrate factual knowledge of science (terminology, organization, classifications, methods, fundamental principles, generalizations, or theories).
2. Use appropriate scientific reasoning skills to interpret and analyze content in the natural sciences.

SLO 2: Students will demonstrate mathematical knowledge and skills.

Criteria for Assessment: Students will be able to

1. Perform the mathematical computations required in the science courses they are taking.

2. Read and comprehend written information relevant to the science courses they are taking.
3. Read and comprehend graphical quantitative information relevant to the science courses they are taking.

SLO 3: Students will be able to demonstrate a fundamental scientific principle.

Criteria for Assessment: Students will be able to

1. Collect data, making appropriate measurements.
2. Precisely record data, including use of appropriate units.
3. Analyze data to determine its relationship to the scientific principle and evaluate the data for errors.

III. Three-Year Cycle for Assessment of Student Learning Outcomes

The faculty agreed on a three-year cycle of assessment for the three program learning outcomes, as shown in Table 1 below.

Learning Outcomes	**'11-12**	**'12-13**	**'13-14**
SLO 1: Students will demonstrate scientific knowledge and skills in scientific reasoning.	X	"12-13	
SLO 2: Students will demonstrate mathematical knowledge and skills.	"11-12	X	
SLO 3: Students will be able to demonstrate a fundamental scientific principle.			X

Table 1. Science General Education Assessment Cycle

IV. Summary of 2012-13 Assessment Activities

During the 2011-12 academic year, the scheduled SLO 1 (scientific knowledge) for assessment was switched with SLO2 (math knowledge) as the math knowledge was assessed by the Biology Program and several courses offered by General Education are also core courses in Biology program curriculum. In 2012-2013 school year, the program faculty conducted formal assessment of SLO #1: Students will demonstrate scientific knowledge and skills in scientific reasoning. This learning outcome has been mapped to the science general education curriculum as shown in Appendix A.

Direct Assessment #1
The faculty conducted an assessment of this SLO in CHE 101 during the Fall 2012 term, using final exam clustered around the two performance criteria. There were 118 students involved in the assessment. The results are shown in Table 2 below.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Demonstrate factual knowledge of science	4 Exam questions	1= correct 0 = incorrect	75% of students got 3 out of 4 of correct	1.7% got 0 out of 4 correct 4.2% got 1 out of 4 correct 10.2% got 2 out of 4 correct 20.3% got 3 out of 4 correct 63.6% got 4 out of 4 correct
Use appropriate scientific reasoning skills to interpret and analyze content in the natural sciences	4 Exam questions	1= correct 0 = incorrect	75% of students got 3 out of 4 correct	1.7% got 0 out of 4 correct 13.6% got 1 out of 4 correct 18.6% got 2 out of 4correct 31.4% got 3 out of 4 correct 34.7% got 4 out of 4 correct

Table 2. Assessment Results for SLO 1 in CHE 101, Fall 2012.

Discussion:
Expectations were exceeded when 83.9% of the surveyed students were able to answer 75% of the questions testing factual science knowledge. On the other hand, only 66.1% of the students met instructors' expectation on the scientific reasoning portion of the assessment.
Factual Knowledge: The fact that instructors' expectations were not only met, but also exceeded suggests that the students were able to successfully memorize terminology and directly apply definitions in order to answer questions.
Scientific Reasoning: Instructors' expectations were not met in the category of scientific reasoning. There may be several underlying causes, including inadequate length of time spent in class discussing the topic, students' difficulty with interpreting word problems, mathematical skills required for solving equations, and lack of confidence in their mathematical or reasoning abilities. Of all the questions on scientific reasoning, one concerning gas laws was missed most often. A way to improve understanding of this topic is to spend more time in class discussing it. The unit on gas laws is usually the last

one of the term and perhaps covering it sooner would ensure that students get more practice and exposure to these ideas. Instructors are also working on improving students' skills to interpret word problems and on building confidence in their ability to do so in a testing situation. To this effect, the examples solved in class are given to students in the form of word problems. Then as a group we determine what information is given, and match known numbers to their corresponding symbols, with the idea that with time it becomes a habit to analyze the given information in every problem before trying to solve it. The fundamental mathematical skills of students improve throughout the term because on the regular basis they are asked to judge numerical relationships, work out fractions, solve equations, and use geometry to calculate volumes of specific shapes. However, it may not be enough. To ameliorate this shortcoming, it may be wise to include more math problems that are worked out in class or on homework assignments, quizzes, and exams in order to emphasize the utmost importance of mathematics in Chemistry. Finally, students' study habits are not to be disregarded. Student success in Chemistry depends on spending much time outside the classroom. Our outcomes may suggest that the students work harder on memorizing definitions and terminology than working out practice examples.

Direct Assessment #2
The faculty conducted an assessment of this SLO in BIO 102 during the winter 2013 term, using final exam clustered around the two performance criteria. There were 37 students involved in the assessment. The results are shown in Table 3 below.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Demonstrate factual knowledge of science	4 Exam questions	1= correct 0 = incorrect	70% of students got 3 out of 4 correct	2.7% got 0 out of 4 correct 16.2% got 1 out of 4 correct 10.8% got 2 out of 4 correct 16.2% got 3 out of 4 correct 54.1% got 4 out of 4 correct
Use appropriate scientific reasoning skills to interpret and analyze content in the natural sciences	4 Exam questions	1= correct 0 = incorrect	60% of students got 3 out of 4 correct	2.7% got 0 out of 4 correct 18.9% got 1 out of 4 correct 27% got 2 out of 4 correct 32.4% got 3 out of 4 correct 18.9% got 4 out of 4 correct

Table 3. Assessment Results for SLO 1 in BIO 102, Winter 2013.

Discussion:
Expectations were met when 70.3% of the surveyed students were able to answer 75% of the questions testing factual science knowledge. On the other hand, only 51.3% of the students met our expectation on the scientific reasoning portion of the assessment, falling short of the goal.
Factual Knowledge: The fact that our expectations met the criteria for acceptable performance was positive, but we would like to exceed this goal by a greater margin. This may be achieved in the future by study and review sessions, more interactive review in the classroom, and more activities involving the students.
Scientific Reasoning: Our expectations were not met in the category of scientific reasoning. Possible causes could include the fact that this is a science course for non-majors, whose primary goal may be to get a science requirement out of the way. Also, integrating factual information into a reasoning process is by its nature more difficult than simple memorization and regurgitation of facts.

Steps to take to improve in this category could include more class discussions utilizing scientific reasoning, homework assignments requiring students to exercise scientific reasoning, in-class activities using individuals and teams to exercise scientific reasoning, and application of questions requiring scientific reasoning in each quiz or exam. These may include interpretation of cladograms and further explanation and work in taxonomic keys. As with factual knowledge, adding more study and review sessions, as well as in-class review may help improve student reasoning skills.

Direct Assessment #3
The faculty conducted an assessment of this SLO in CHE 222 during the winter 2013 term, using final exam questions clustered around the two performance criteria. There were 45 students involved in the assessment. The results are shown in Table 4 below.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Demonstrate factual knowledge of science	4 Exam questions	1= correct 0 = incorrect	75% of students got 3 out of 4 correct	0% got 0 out of 4 correct 4.4% got 1 out of 4 correct 20% got 2 out of 4 correct 44.4% got 3 out of 4 correct 31.1% got 4 out of 4 correct
Use appropriate scientific reasoning skills to interpret and analyze content in the natural sciences	4 Exam questions	1= correct 0 = incorrect	75% of students got 3 out of 4 correct	0% got 0 out of 4 correct 6.7% got 1 out of 4 correct 22.2% got 2 out of 4 correct 24.4% got 3 out of 4 correct 46.7% got 4 out of 4 correct

Table 4. Assessment Results for SLO 1 in CHE 222, Winter 2013.

Discussion:
Overall, students met instructor's expectation on this assessment. This is the second term students took this series of General Chemistry, and instructor felt students should be more competent in mastering Chemistry. It is worthwhile to note that the instructor provided extensive help to students studying this course, including weekly study sessions, home works, exercise packages, and extra tutoring during laboratory time. All these may contribute to the success of students' performance.

Direct Assessment #4
The faculty conducted an assessment of this SLO in PHYS 222 during the winter 2013 term, using final exam questions clustered around the two performance criteria. There were 42 students involved in the assessment. The results are shown in Table 5 below.

Performance Criteria	Assessment Method	Measurement Scale	Minimum Acceptable Performance	Results
Demonstrate factual knowledge of science	Exam questions	1= correct 0 = incorrect	75 % of students should get at least 3 out of 4 correct	9.5% got 0 out of 4 correct 31.0% got 1 out of 4 correct 16.7% got 2 out of 4 correct 35.7% got 3 correct 7.1% got 4 out of 4 correct
Use appropriate scientific reasoning skills to interpret and analyze content in the natural sciences	Exam questions	1= correct 0 = incorrect	75 % of students should get at least 3 out of 4 correct	0.0% got 0 correct 9.5% got 1 correct 23.8% got 2 correct 47.6% got 3 correct 19.0% got 4 correct

Table 5. Assessment Results for SLO 1 in PHYS 222, Winter 2013.

Discussion:
The physics faculty who performed this assessment expected that 75% of students should be at least 75% proficient on both of the above learning outcomes. As apparent from the assessment results reported in the above table, neither of these expectations was met. Interestingly, students in PHY 222 displayed significantly higher performance in scientific reasoning (66.6% of students were 75% proficient or better) than in factual knowledge (42.8% of students were 75% proficient or better). We believe this may be due to two factors. First, in this section of PHY 222, significant emphasis was placed on quantitative problem solving and conceptual reasoning, which are two important learning objectives for the course. In conjunction with the overall student performance in the course (course average was 80%) the results from the factual knowledge assessment indicate that a significant number of students can solve problems quantitative and conceptually, but may still lack basic knowledge of how certain quantities are defined (factual knowledge). It therefore cannot be assumed that the ability to identify and calculate a particular physical quantity indicates understanding of

what that quantity represents. The assessment results indicate an increased emphasis on demonstrating factual knowledge is needed in this course, i.e. students apparently do not obtain this proficiency as a natural side effect of working toward the other learning objectives for the course. Second, a large portion of PHY 222 focuses on electricity and magnetism, which are conceptually difficult topics for students to master. Student performance was lowest on the two factual knowledge assessments that involved stating the definition of electric field and electric potential. Again, we found that students who demonstrated the ability to perform calculations involving these quantities could not adequately articulate what these quantities represent. This is not entirely surprising, since these concepts are very abstract and present considerable conceptual difficulties for students. Although student performance on demonstrating scientific reasoning was significantly better, students still did not meet the instructor's expectations.

Direct Assessment #5
The faculty conducted an assessment of this SLO in PHYS 222 during the winter 2013 term at Wilsonville campus, using final exam questions clustered around the two performance criteria. There were 42 students involved in the assessment. The results are shown in Table 6 below.

Performance Criteria	**Assessment Method**	**Measurement Scale**	**Minimum Acceptable Performance**	**Results**
Demonstrate factual knowledge of a science	Exam question	1 = correct 0.5 = partially correct 0 = incorrect	70% of students should get at least 3 out of 4 correct	6.25% got less than 1 out of 4 correct 12.1% got 1 out of 4 correct 12.5% got 2 out of 4 correct 25.3% got 3 out of 4 correct 43.5% got 4 out of 4 correct
Use appropriate scientific reasoning skills to interpret and analyze content in the natural sciences	Exam question	1 = correct 0.5 = partially correct 0 = incorrect	70% of students should get at least 3 out of 4 correct	25% got less than 1 out of 4 correct 43.7% got 1 out of 4 correct 25% got 2 out of 4 correct 6.3% got 3 out of 4 correct 0% got 4 out of 4 correct

Table 6. Assessment Results for SLO 1 in PHYS 222, Winter 2013.

Discussion:
The average exam score for the class was 56.6% which is 20% points lower than average final exam scores for previously taught PHY222 courses. On average, students scored 74.2% correct on the Factual Knowledge criteria. In aggregate, though, 68.8% of the students scored at least 3 out of 4 for this criterion. This is close to but below the goal of 70%.
On average, students scored 32.8% correct on the Scientific Reasoning criteria. In aggregate, though, only 6.3% of the students scored at least 3 out of 4 for this criterion. This is far below the goal of 70%.
By taking a ratio of each criteria percentage over the average exam score, how well the exam measured each of the criteria can be ascertained. The ratio for Factual Knowledge was 1.31 showing that students were very capable of demonstrating their

factual knowledge despite losing points in other areas on the exam; also this shows that the exam was a good measure of this skill.
The ratio of criteria percentage over average exam score for Scientific Reasoning was 0.58 showing that students did not demonstrate scientific reasoning skills but were able to make up for it in other areas on the exam; this also shows that the exam was not a good measure of this skill.
In conclusion, the instructor felt it is necessary to work on helping students better identify the problem type in order to apply their factual knowledge appropriately and to focus more effort on preparing students with scientific reasoning skills.

V. Summary of Student Learning

SLO 1: Students will demonstrate scientific knowledge and skills in scientific reasoning.

Strengths: Students taking BIO 101, BIO 102 and CHE demonstrated satisfactory performance in factual knowledge assessment, showing that students were able to successfully memorize terminology and directly apply definitions in order to answer questions.

Weaknesses: Four out of five assessments in the performance of scientific reasoning demonstrated a deficiency in this criterion. Students had difficulty with interpreting word problems and mathematical skills required for solving equations. Some concepts are very abstract, especially in physics, and present considerable conceptual difficulties for students. In addition, results from the factual knowledge assessment in physics classes indicated a weakness in factual knowledge, and results from one of the physics class showed that a significant number of students can solve problems quantitative and conceptually, but may still lack basic knowledge of how certain quantities are defined.

Actions: Steps to take to improve in this category could include more class discussions utilizing scientific reasoning, homework assignments requiring students to exercise scientific reasoning, in-class activities using individuals and teams to exercise scientific reasoning, and application of questions requiring scientific reasoning in each quiz or exam.
There are a number of actions the physics faculty are/will be pursuing that are expected to improve performance on the two above learning objectives in the physics sequence:

- reevaluating course content and learning objectives for the entire introductory sequence. It is expected that the amount of content in the sequence will be reduced, allowing more time to be spent on the more conceptually challenging topics such as electricity and magnetism.
- integrating a recitation-style component into the laboratory portion of the course, to provide enhanced, guided opportunities to apply course material in smaller groups. We expect this will improve problem solving skills and provide more opportunities for students to use conceptual reasoning skills.

- Exercises and activities will be integrated into assignments that emphasize/require understanding of the meaning and definition of important physical quantities.

Appendix A: PSLO #1 Mapped to the Science General Education Curriculum Map

SLO 1: Students will demonstrate scientific knowledge and skills in scientific reasoning.

This is a list of courses that are considered part of the General Science Education program at Oregon Institute of Technology. Courses that are shaded below indicate that PSLO #1 is taught in the course.

	100 Level			**200 Level**	
FALL	CHE 101	Elementary CHE		CHE 201/CHE 221	General CHE
	BIO 101	General BIO		BIO 200	Medical terminology
	BIO 111	Intro Env. Science		BIO 211	Principles of BIO
				BIO 231	Human A&P I
				PHYS 201	General PHYS
				PHYS 221	General PHYS w/calc
				PHYS 223	General PHYS w/calc
WINTER	CHE101	Elementary CHE		CHE 202/222	General CHE
				BIO 212	Principles of BIO
	BIO 102	General BIO		BIO 232	Human A&P II
	BIO 105	Microbiology		PHYS 202	General PHYS
				PHYS 221	General PHYS w/calc
				PHYS 222	General PHYS w/calc
SPRING	CHE 101	Elementary CHE		CHE 223	General CHE
				CHE 235	Streamwater chemistry and Sampling
	BIO 103	General BIO		BIO 213	Principles of BIO
				BIO 216	Intro to Vet. Medicine
				BIO 233	Human A&P III
				PHYS 203	General PHYS
				PHYS 222	General PHYS w/calc
				PHYS 223	General PHYS w/calc