Program Plan and Findings: Four Column Layout

Program (CAS) - CHEM - Chemistry: Departmental Degree (BS) - 044

Program Mission Statement: The Department of Chemistry at Oklahoma State University: promotes the advancement and dissemination of knowledge that is central to many science reliant degree programs both within A&S and across College lines; nurtures the growth of future scientists through undergraduate and graduate research; supports creative endeavors in innovative instruction paradigms and scientific research by faculty and staff; enriches civilization by contributing to education and new technological developments.

Program Information

2019 - 2020

Program Information

Assessment Coordinator's Name: Jacinta Mutambuki, Ph.D.
Assessment Coordinator's E-mail Address: jacinta.mutambuki@okstate.edu
Number of Students Enrolled in the Program: 32
Total Number of Students Graduated: 2
Number of Student Graduates from Stillwater Campus: 2
Number of Student Graduates from Tulsa Campus: 0
Were university assessment funds used by the department/program for assessment activities?: Yes
If yes, describe how funds were used and the contribution the funds had on the assessment process: Funds were used for reviewing artifacts and analyzing the data.

Annual Executive Summaries

2019 - 2020

Program Assessment Coordinator: Jacinta Mutambuki, Ph.D.

Plan Review and Approval

Date Current Plan Was Reviewed and Approved:
Date of Future Plan Review and Approval:

Summary of Assessment Findings

Describe overall assessment findings and faculty members' interpretation of the assessment results: Overall, results indicated that most students in the assessment sample demonstrated scientific reasoning and critical thinking skills below the departments' expectation. Furthermore, students in introductory level courses, such as CHEM 1515, demonstrated the least scientific reasoning and critical thinking skills in nearly all the categories compared to students in the advanced courses, such as 3053 and 3153. Overall, results reveal improved development of scientific reasoning and critical thinking skills as students progress through the program; however, the development is

below the expectations of the program on this outcome, and not exclusively linear as students in the advanced courses (e.g., CHEM 3153) demonstrated the least scores on the calculations component. Overall, results imply the need for innovations to enhance student development of scientific reasoning and critical thinking skills on all the components assessed. About 44% scored above 3.5 for this outcome.

Results further indicated that communication of research findings in the form of written reports (e.g. CHEM 4990) were merely adequate. There are clear deficiencies in student skill in awareness of and referencing the broader scientific literature. Skills in graphical presentation of data are not being adequately developed. Scientific thought, construction of text, and organization of the written word are all well demonstrated in written reports, indicating that students are applying their interpretation and language skills quite well. These findings indicate that while students are receiving the basics of scientific communication, stronger individual mentorship and oversight is likely needed for students to demonstrate advanced abilities in scientific writing.

Dissemination of Findings

Describe the individual(s) or committee responsible for reviewing and interpreting assessment data: Dr. Jacinta Mutambuki is the Assessment Coordinator and Assistant professor, and Dr. Christopher Fennell is Associate Professor and an active member of the Assessment Committee.
Describe the process for sharing and discussing assessment findings with program faculty: The assessment results will be discussed during a general chemistry faculty meeting.

Program Improvements Based on Assessment

Based on data collected this year, what changes are being considered or planned for the program?: Results will be shared with the chemistry faculty to deliberate on suitable adjustments in restructuring the courses and assessments to bolster student development of scientific reasoning and critical thinking skills in the courses. Particular emphasis on improving student writing and communication skills will be strongly recommended for the CHEM 4990 course.
Based on this year's findings, what (if any) changes are planned for the assessment process?: The Assessment Committee suggests a number of changes to improve the data collection process in the near future. First, plans are underway to collect copies of the relevant artifacts for assessment in the subsequent assessment period before professors return them to students. Second, the assessment team will work with the instructors to collect screenshots of students' work on their thought processes during problem solving in multiple-choice type of exams. Third, for future assessments, we will administer a survey to students in the program to uncover their experiences in the program and suggestions for improvement.

Describe the process for implementing these changes/planned program improvements: For data collection improvements, the assessment team will work with the program advisor to identify students enrolled in the program and the courses they are enrolled in each semester. This will ensure timely follow up with the course instructors to collect the assessment artifacts before they are returned to the students. This effort will be implemented each semester to ensure adequate sample is realized for analyses.

To overcome the challenges of multiple-choice questions following remote instruction, course instructors will be encouraged to request the students to submit screenshots of their reasoning processes on problem-solving questions to enable analysis of scientific reasoning and critical thinking skills on closed-ended questions

A student survey will be administered through Qualtrics to capture students' experiences in the program including barriers to excelling in the program (CHEM courses), and any suggestions for future improvement of the program.

Program Improvements Made in the Last Year: Assessment Measure Improvements
"Other" Improvements:
Goals for the Coming Year: Revise the assessment plan for quality data collection, and refine the SLOs for more measurable and achievable outcomes.
Is this Summary Report Complete?: Yes
List all individuals associated with this report preparation: Drs. Jacinta Mutambuki Dr. Christopher Fennell.

Outcomes	Assessment Methods	Findings	Use of Findings (Actions)
Scientific Reasoning - Students will know and be able to apply scientific reasoning to principles important to foundational concepts in chemistry. **Outcome Status:** Active **Planned Assessment Year:** 2016 - 2017, 2017 - 2018, 2018 - 2019, 2019 - 2020, 2020 - 2021, 2021 - 2022, 2022 - 2023 **Start Date:** **Archived Date:** **Outcome Type:** Knowledge **Reason for Archival:**	**Analysis of Written Artifacts -** Student artifacts were collected during the Spring, 2017 semester in CHEM 3112. Student names will be redacted from the artifacts. Scientific reasoning and problem solving skills were assessed using a modified science reasoning rubric developed in the Chemistry Department. *** Learning Outcome** **Goal/Benchmark:** 70% of students will receive a 3, 4 or 5 using the science reasoning rubric. **Timeline for Assessment:** Yearly **Other Assessment Type:**		
	Analysis of Written Artifacts - A total of 3 chemistry majors enrolled in the BS-DEPT degree were included. One student was from CHEM 1314 (Summer 2019), and two were from CHEM 3433 and 3553 (Fall 2018 and Spring 2019). A list of undergraduate chemistry majors was obtained from the Department of Chemistry, including information about the courses they took during Fall 2018, Summer 2018, and Spring 2019 semesters. The identified chemistry majors enrolled in the courses of interest (CHEM 1314, 3433, and 3553) during these semesters were included in the assessment of this outcome. Assessments involved rating students' artifacts and correlational analysis on formative assessment. The latter was only implemented in CHEM 3433 and 3553. For analyses of artifacts, three chemistry faculty		

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	members and one graduate chemistry student were involved. The artifacts were mainly exam questions from the final exam or from both final and midterm exams on the courses previously mentioned. Two raters independently assessed the artifacts against a Scientific Reasoning and Critical Thinking Rubric, which is attached in the Appendix section and discussed the rating scores. For example, for CHEM 3433 and 3553, one faculty and the graduate student independently rated 35 artifacts of six chemistry majors and discussed the generated rating scores. Differences in the rating were discussed and resolved, with an agreement of more than 90% reached. Similar procedure was applied in rating artifacts from CHEM 1314 (6 artifacts of one student on the final exam) in which two faculty members were involved. The artifacts were scored on six components (if at all present on the artifacts), namely: Understanding of Problem; Graphical Interpretation; Calculations; Solution and Data Interpretation; Answer and Use of Terms; and Representations and Models. The rating scale on these components were 1 (least score), 3, and 5 (highest score); however, a score of 2 and 4 were assigned if the assessed artifact displayed characteristics features between 1 and 3, and between 3 and 5, respectively. Finally, the faculty reviewed the final tallied scores		

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	from all the artifacts to ensure the rating were done within the scale and no reporting errors on the scores. Assessments involved rating students' artifacts and correlational analysis on formative assessment. The latter was only implemented in CHEM 3433 and 3553. For analyses of artifacts, three chemistry faculty members and one graduate chemistry student were involved. The artifacts were mainly exam questions from the final exam or from both final and midterm exams on the courses previously mentioned. Two raters independently assessed the artifacts against a Scientific Reasoning and Critical Thinking Rubric, which is attached in the Appendix section and discussed the rating scores. For example, for CHEM 3433 and 3553, one faculty and the graduate student independently rated 35 artifacts of six chemistry majors and discussed the generated rating scores. Differences in the rating were discussed and resolved, with an agreement of more than 90% reached. Similar procedure was applied in rating artifacts from CHEM 1314 (6 artifacts of one student on the final exam) in which two faculty members were involved. The artifacts were scored on six components (if at all present on the artifacts), namely: Understanding of Problem; Graphical Interpretation; Calculations; Solution and Data		

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	Interpretation; Answer and Use of Terms; and Representations and Models. The rating scale on these components were 1 (least score), 3, and 5 (highest score); however, a score of 2 and 4 were assigned if the assessed artifact displayed characteristics features between 1 and 3, and between 3 and 5, respectively. Finally, the faculty reviewed the final tallied scores from all the artifacts to ensure the rating were done within the scale and no reporting errors on the scores. The formative/summative correlation effort was also made in an attempt to evaluate a pilot effort to potentially improve student success in the historically challenging/troubling Physical Chemistry sequence. In this course pairing, students are grouped with engineering students that have already had significantly greater preparation in foundational course concepts, often placing ACS (and Departmental) Degree Chemistry majors at an initial disadvantage. This pilot effort involved the introduction of a 4th midterm exam, this to distribute the summative assessment workload over smaller allotments of course material, giving the Chemistry majors a more manageable study workload before examinations. Correlation analysis of in-class formative assessment versus summative assessment was performed, though the major		

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	numbers changed from four students in 2017/2018 to eight students in 2018/2019. The difference between years leads to added statistical uncertainty for results from the 2017/2018 academic year, though the results appear to be significant enough to draw unbiased conclusions regarding the pilot effort. *** Learning Outcome** **Goal/Benchmark:** 75% of students will receive aggregate 3.5 or higher score across all the categories using the science reasoning and critical thinking rubric. **Timeline for Assessment:** Yearly **Other Assessment Type:** Rating of skills (e.g., Rubrics), and Formative/summative Correlational Anayses **Related Documents:** Science Reasoning and Critical Thinking Rubric.docx		
	Analysis of Written Artifacts - One graduate student and one faculty were involved in the analysis of the artifacts. The two individuals together identified exams questions that could be assessed using the Scientific Reasoning and Critical Thinking Rubric, which is attached in the Appendix section. The artifacts were scored on six components (if at all present on the artifacts), namely: Understanding of Problem; Graphical Interpretation; Calculations; Solution and Data Interpretation; Answer and Use of Terms; and Representations and	**Reporting Period:** 2019 - 2020 **Conclusion:** 1 - Does Not Meet Program Expectations (Unacceptable) Results indicated an average mean rating score of 3.0 ±0.4 (average with standard deviation) on the SLO 1, science reasoning and critical thinking skills for all the students assessed for this degree pathway (Table 2, Appendix). The mean rating was below the expected value by a 0.5 point. Overall, only two components of the SLO 1, “Answer and use of terms” and “Representation of models” showed close mean rating scores to the projected mean, that is 3.6 and 3.4, respectively. The remaining four components indicated mean rating scores below the expected mean. Specifically, Graphical interpretation and Calculations were associated with a mean rating score of 3.0 each, whereas Understanding problem and “Solutions and Data	**Use of Findings (Actions):** Findings indicate a critical need for improvement on all the assessed components of this SLO. (09/13/2020)

Outcomes	Assessment Methods	Findings	Use of Findings (Actions)
	Models. The rating scale on these components were 1 (least score), 3, and 5 (highest score); however, a score of 2 and 4 were assigned if the assessed artifact displayed characteristics features between 1 and 3, and between 3 and 5, respectively. The two individuals together coded three exam questions, and the rest were coded by the graduate student. The coded artifacts and the rating scores were audited by the faculty member to ensure accuracy in coding. Discrepancies in coding were discussed and resolved, with 100% agreement reached. Tallying of the scores was performed by the graduate student. For example, for a given artifact item, if we had let's say X questions which had a "calculation" component and the student could answer only Y questions correctly, then a score of Y/X proportion was given for the calculation component to the student. Finally, the faculty reviewed the final tallied scores from all the artifacts to ensure the rating were done within the scale and no reporting errors on the scores. We note that the current assessment period saw a drastic decrease in the number of students assessed due to the covid-19 pandemic, in which transition into remote instruction culminated to overuse of multiple-choice questions in most chemistry courses, particularly in spring 2020. For Fall	interpretation" were associated with mean rating scores of 2.8 and 2.4 points, respectively (Table 2, Appendix). (09/13/2020) **Number of Students Assessed:** 9 **Number of Successful Students:** 4 **How were students selected to participate in the assessment of this outcome?:** A list of undergraduate students enrolled in the CHEM (DEPT) degree path was obtained from the Department of Chemistry, including information about the courses they took during Fall 2019 and Spring 2020 semesters. Students enrolled in the chemistry courses during 2019-2020 we considered in the assessment. **What do the findings suggest about student achievement of this learning outcome?:** Overall, current results suggest that the preparation pathway for students in the CHEM Departmental degree is below average and students do not demonstrate robust scientific reasoning and critical thinking skills they are expected to have from the chemistry courses. **Related Documents:** Science Reasoning and Critical Thinking Rubric.docx Appendix Table 2_CHEM Departmental Degree Pathway.pdf	

Outcomes	Assessment Methods	Findings	Use of Findings (Actions)
	2019 chemistry courses, artifacts were handed back to students immediately after grading; thus, making it difficult to assess a large pool of students for this degree program. Nine out of 32 students (~ 28%) enrolled in the program were assessed during this period. The assessed students were enrolled in CHEM 1515 (n = 1), CHEM 3053 (n = 3), and CHEM 3153 (n = 5). A total of 53 artifacts measuring specific components of the SLO 1 were included in the analyses. *** Learning Outcome** **Goal/Benchmark:** 75% of students will receive aggregate 3.5 or higher score across all the categories using the science reasoning and critical thinking rubric. **Timeline for Assessment:** Yearly **Other Assessment Type:**		
Writing Communication Skills - Students will be able to demonstrate proficiency in writing skills and accurately apply scientific literature in completing their project in CHEM 4990 **Outcome Status:** Active **Planned Assessment Year:** 2019 - 2020, 2020 - 2021, 2021 - 2022 **Start Date:** **Archived Date:** **Outcome Type:** Skills **Reason for Archival:**	**Rating of Skills -** Two faculty were involved in the collection and eventual analysis of the artifacts. Repeated blind analysis of all artifacts were performed and score on the 5 components listed in the rubric for assessment of written reports, namely: Critical Thinking, Scientific Support, Organization, Grammar/Spelling, and Visual Presentation. The rating scale on these components were 1 (least score), 2, 3, and 4 (highest score). The scoring assessment was independently repeated and the average component scores for each	**Reporting Period:** 2019 - 2020 **Conclusion:** 1 - Does Not Meet Program Expectations (Unacceptable) Results indicated an average mean rating score of 2.6 ±0.5 (average with standard deviation) on the SLO 3, science writing skills for all the students assessed in this degree pathway (Table 2). The mean rating was higher than the expected value by a 0.1 point. Overall, three components of the SLO, “Critical Thinking”, "Organization", and “Grammar/Spelling” showed mean rating scores above the projected mean, 3.0 in all cases. The remaining two components indicated mean rating scores below the expected mean. Specifically, "Scientific Support" and "Visual Presentation" were both associated with a mean rating score of 2.0 each (Table 2). (09/13/2020) **Number of Students Assessed:** 2	**Use of Findings (Actions):** Findings indicate a clear need for improvement on all the assessed components of this SLO, with proper literature review and citation skills and visual communication of data in need of particular emphasis. (09/13/2020)

Outcomes	Assessment Methods	Findings	Use of Findings (Actions)
	artifact were recorded. Finally, the faculty reviewers gathered and cross-checked the final tallied scores from all the artifacts to ensure the rating were done within the scale and no reporting errors on the scores. We note that the current assessment period saw a drastic decrease in the number of students assessed due to the covid-19 pandemic, particularly in spring 2020. CHEM 4990 requires regular student and faculty interaction as it is an independent study course, and such interactions are difficult when done in a remote manner with restricted access to campus resources. In the end, only 2 full student report artifacts contributed to the components of the SLO 3 analyses. *** Learning Outcome** **Goal/Benchmark:** 75% of students will receive an aggregate 2.5 or higher score across all the categories using the assessment of written reports rubric. **Timeline for Assessment:** Yearly **Other Assessment Type:**	**Number of Successful Students:** 1 **How were students selected to participate in the assessment of this outcome?:** The identified chemistry majors enrolled in CHEM 4990 during the two semesters for which final reports were returned by mentoring faculty were considered in the assessment of this outcome. **What do the findings suggest about student achievement of this learning outcome?:** Current results suggest that the preparation pathway for students in the CHEM Departmental degree is encouraging, but not very far off the middle point expectation set by the rubric for written reports (Appendix IV). Of the reports considered only 50% of the students exceeded this middle point threshold, not the desired 75%.	