Ohio Transfer 36 Guidance Document:

Natural Sciences

Table of Contents

Introduction....3
Components of a Submission for Ohio Transfer 36....4
Tips....6
Natural Sciences Submission Specifics....7
Natural Sciences Exemplars....11

Introduction

This document provides an overview of how to prepare course materials for submission to Ohio Transfer 36, which guarantees student transfer of general education coursework among public institutions in the state. As institutions prepare to make submissions in the Course Equivalency Management System (CEMS), individuals involved in the process (faculty, administrators, and staff) should use this guidance document to become familiar with the steps required for a course to be approved for inclusion in Ohio Transfer 36. This effort entails collaboration of people in many roles on Ohio's campuses and at the Ohio Department of Higher Education. The ultimate goal is a high-quality, meaningful educational experience for Ohio's students.

If you have questions after reading this guidance document, contact: Michelle Blaney, Associate Director, Articulation & Transfer Policy at mblaney@highered.ohio.gov or Jessi Hart, Senior Director, Articulation and Transfer Policy, Budget, and Constituent Relations at jhart@highered.ohio.gov.

Components of a Submission for Ohio Transfer 36

1. **Course Details Form**

- This document will help your institution complete the Course Details page in CEMS.
- Be sure that the information on the Course Details Form matches the syllabus and other documentation in the submission.
- Ohio Transfer 36 coordinators should work with faculty subject matter experts to complete Course Details Forms.

2. **Learning Outcome Template**

- This document will allow faculty who are familiar with the course to provide brief statements that indicate how it fulfills each of the Ohio Transfer 36 learning outcomes.
- Because Ohio Transfer 36 focuses on learning outcomes, please describe what the course requires students to do, not simply the topics the course covers.
- For each learning outcome, CEMS responses should address:
    A. **the specific course outcomes and related content through which students achieve this Ohio Transfer 36 learning outcome.** What course materials and activities relate to this outcome?
    B. **assessment of student achievement of this Ohio Transfer 36 learning outcome.** How do instructors determine the degree to which students have met this outcome?
    C. **key locations in the attached course documents that demonstrate student focus on this Ohio Transfer 36 learning outcome.** Where in the submitted course documents (syllabus, assignments, etc.) can faculty reviewers find content, activities, and/or assessments related to this outcome? Identify several key examples to demonstrate the importance of the outcome in the course. Please avoid referring to the same assignments repeatedly to explain how the course meets each of the outcomes. Include a variety of activities in your explanations to show that the course as a whole emphasizes the Ohio Transfer 36 outcomes.
- Please label the parts of each learning outcome response as A, B, and C.
- Responses need not be lengthy. Think of the CEMS responses as guides to the attached course documents, highlighting the most important elements on which reviewers should focus for each Ohio Transfer 36 learning outcome.
- Please avoid copying and pasting material that's available elsewhere in the submission (for example, in the syllabus). The CEMS learning outcome responses are intended to allow faculty to provide clear, concise explanations to other faculty (the members of Ohio Transfer 36 review panels) about how the course supports Ohio Transfer 36 learning outcomes.

- Text entered into CEMS won't incorporate advanced formatting (for example, bullet points, indenting) from word processors, so please use simple text and spacing.

3. Supporting Documents

- Upload **an up-to-date working syllabus** that includes:
  - course learning outcomes. Course learning outcomes should support—but need not be identical to—the Ohio Transfer 36 learning outcomes.
  - information about the course textbook and/or other readings (if applicable). For open educational resources, links are helpful.
  - a detailed calendar of readings and activities. Please provide clear identifying information for the reading assignments on the schedule (authors, book/article/chapter titles, etc.). Dates should be recent but need not be current.
  - a list of graded assignments with points/weights/percentages for each assignment.
- Upload **sample activities/assessments** that demonstrate student achievement of the Ohio Transfer 36 learning outcomes.
- Please limit the number of attachments and use file names that will allow panel members to easily identify each document.
- A master syllabus is acceptable in place of a working syllabus as long as the information listed above is included. Some master syllabi don't include a detailed calendar/schedule for the term.
- A master syllabus (in addition to a working syllabus) is often helpful in outlining the required elements of a course regardless of instructor or delivery method. A working syllabus may provide a representative example of how the course is taught, but the institution should be committed to meeting the Ohio Transfer 36 learning outcomes in all sections of a course.
- If a course has not yet been offered, the submitter should still provide the information listed above so that the panel can evaluate each learning outcome.

Tips

- **Submit early!**
  - Allow yourself an extra review cycle or two before a deadline in case it becomes necessary to do a resubmission.
  - Just because a submission was returned, that doesn't mean that it was rejected by the review panel. OATN staff will sometimes make suggestions for improving a submission before it is forwarded to the review panel, especially if it seems likely that the panel will request missing information.
  - Please don't wait until the submission deadline of a review cycle to send in submissions. You should leave time for OATN staff to resolve any possible issues with the submission while still allowing them to forward it to the review panel on time.
- If you would like OATN staff to review materials before submitting in CEMS, please reach out in advance of the review cycle deadline.
- If your institution would like to connect with an Ohio Transfer 36 faculty review panel lead, please reach out to OATN staff to schedule a meeting.
- If a panel's review comment is not clear, please send OATN staff an email. We may be able to provide additional information.
- If faculty members from your institution serve on review panels, take advantage of their expertise and guidance even if they are not preparing the submission. A list of faculty panel members from your institution can be obtained by sending OATN staff an email.
- Check out the OATN newsletter! There is a section devoted to Ohio Transfer 36, TAG, and CTAG submissions. Updates and deadlines are often mentioned in the articles, along with a link to the complete submission and review timeline, to help you prioritize your institution's submissions.
- If you asked CEMS to reset your password and have not received an email from "ATC-Help" within five minutes, please contact OATN staff immediately. CEMS will not tell you if you are using the wrong user ID.
- We are all in this together! If for whatever reason you are stuck, please feel free to contact OATN staff.

Natural Sciences Submission Specifics

Excluded courses:

- Remedial or developmental courses, special topics courses, narrowly focused courses, technical or pre-technical courses and skills-based courses.
- Courses that focus exclusively on content coverage without addressing the learning outcomes for the Ohio Transfer 36. Career preparation courses, non-credit continuing education courses, life experience courses (unless life experience credit, such as military training or other prior learning experience, is approved in the future for an Ohio Transfer 36 credit by the statewide faculty review panel).

Ohio Transfer 36 Natural Sciences Lab Course: Attach a document titled “lab memo” which should include a short narrative confirming the mode of delivery, indicating the credit hours assigned to the course or how it is a component of a larger course, and describing how it involves at least 1500 minutes of lab activities. The lab memo document should also include a list and describe, in a few sentences, at least 10 labs in which “students will demonstrate the application of the methods and tools of scientific inquiry appropriate to the discipline, by actively and directly collecting, analyzing, and interpreting data, presenting findings, and using information to answer questions.” **Reason** – The Panel will need to be able to validate that two-thirds of the lab hours involve bona fide, experimental lab activities utilizing the scientific method (identifying/collecting data, manipulating data, evaluating and analyzing data). To that same document append at least one example of a laboratory exercise from the course

Most common source of rejections for laboratory courses: When we look at any laboratory course proposal there are four aspects of those proposals that most often raise red flags and may lead to the rejection of the submission:

1) Inadequate descriptions of laboratory activities and no examples of assessments (see lab memo document above)

2) The labs are all observational with no opportunity to experience the variability of real data. For example, in a botany class, if all the labs are dissecting parts of plants and identifying the anatomical parts of plants this is not a general education science lab. Learning the proper use of a microscope and identifying cell types on a slide is important, but not every lab can involve mostly observation and memorization of discipline-specific terminology. The review panel often spends time counting the number of labs that include at least some part of the scientific method happening. It might be measuring things which then need some statistical analyses, it might be making predictions and devising testable hypotheses from observations and then testing them (maybe via data given to them not actually performed in the lab) and so forth. The panel wants to see 2/3 of the labs having some scientific process experience for the student so typically we are counting to see if 10 of the labs of a 15-week course involve meaningful experiences with science. We often receive lab courses in which 3 weeks are used for exams or lab practice and

some others involve primarily identification and memorization which hardly require an instructor's presence and involve no meaningful interaction with the students. What are the aspects of the scientific method we would like to see?

- Understanding of hypothesis and theory from previous data and scientific knowledge
- Testing the hypothesis with an experiment
- Taking real measurements, some of which shows natural variability
- Data analysis and interpretation through graphing, averaging, calculations or other standard methods. Such as determining a value from the slope of graphed data.
- Understanding that if the results do not support the hypothesis that the hypothesis requires modification of small or large proportions.

3) Lack of instructor involvement/feedback. Many distance/virtual laboratory courses don't include evidence that the instructors will do anything but grade worksheets, manage the course website, and give out the final grade. This demonstrates a lack of synchronous, feedback to the students. This is a sure way to find rejection!

4) Not having enough lab time. We really do look for an accounting of the minimum amount of time spent in laboratory. If, based on the materials provided, we think the labs can be done by students in 15 minutes and there are several lab times devoted to introduction and exams/quizzes we will ask to see much more evidence that there is student engagement in learning science by doing science.

Course Resubmissions: For resubmissions the Natural Sciences panel highly recommends providing a written narrative in a separate document. That document should be clearly titled (e.g., Responses to Panel Concerns) and should include a copy of the panel comments from the returned submission followed by your responses. Those responses should direct the panel members to any other documents where supporting information may be found.

Distance/virtual laboratory course proposals and the meaning of the last two bullet points of our laboratory policy:

- "involves synchronous feedback[2] on safety (and consequences of unsafe actions), correctness of procedure, and progress toward experimental goals; and
- "involves effective interaction with the instructor at several points during each lab activity"

Below is the interpretation of the Ohio Transfer 36 Natural Sciences panel of these outcomes for laboratory course submissions and especially those proposed for distance/virtual format.

The sentiment is two-fold. Lab safety procedures are an important, although not primary, part of the scientific method. In some disciplines concerns about safety is obvious, such as in chemistry with caustic chemicals and open flames, but any natural science lab will also have concerns about individual student safety and the safety of the community. Ideally, in an in-person lab students would receive instructions and reminders about precautions to take or put in place just before and probably during the time that person is engaged in that process. You can write all of these things down and require students read them prior to attending class and have a quiz to give them incentive to take them seriously, but in a live lab the lab instructor is also going to be reminding students of safety and providing feedback to students that are not engaged in proper procedures.

This experience is difficult to replicate in a distance /virtual lab in which the student is likely working alone. The spirit of this portion of the guidelines is to encourage distance/virtual laboratory courses to find creative ways to provide synchronous feedback to students as they perform the lab itself rather than just providing a before-lab video and maybe some reflection questions afterward. We recognize that this is not easy to accomplish. For some courses this may not be of great importance because the safety considerations are not as important (the things that could happen are not as bad as others). For those lab activities, pre-lab videos containing general considerations are all one would probably require.

But for many labs, live or near-live feedback is desirable. This might include a requirement that labs be performed within certain timeframes when an instructor/teaching assistant is online and able to watch or at least hear what is happening. The student might be required to "check-in" during the time when they are doing the lab and talk to an assistant just to say what they have done, have them ask a few questions and give feedback based on their answers. This would be similar to the TAs role in an in-person lab as they walk around to tables, observing and asking questions to be sure each group of students are following procedures. This would not necessarily have to occur for every laboratory exercise.

An Ohio Transfer 36 submission could outline several labs that involve particular safety concerns showing how those safety issues are addressed in those labs. But all labs need not have this type of interaction and feedback. For example, maybe there are two labs that have opportunities to teach about particular safety concerns in the discipline. Over the whole semester the students could be given a set of "lab times" in which they choose to be engaged in those particular labs and will be engaged through a streaming platform with an instructor while doing a portion of that lab.

Secondly, synchronous feedback is not just about safety! It is the view of the panel that learning the scientific method is an essential part of the general education experience. The scientific method is not simply a formula or list of things to do but a way of thinking and organizing one's ideas and testing those ideas. Ideally students should be required to follow all or at least portions of the process of asking questions from observations, coming up with testable hypotheses and testing those hypotheses. In class students should be engaged with instructors in the process of developing and testing ideas from observations and experimental data. The best way to do that is with an active instructor and/or groups of students talking with each other. When the Ohio Transfer 36 panel assesses a distance/virtual course proposal they are looking for places during the course where students are given feedback on their ideas for testing hypotheses and how they draw conclusions from their tests, or data they are given that model the type of data that scientists could collect, and then propose next steps in the process. Not all labs need be this involved but each need to have some component of the scientific method embedded in the laboratory exercise and report.

This "synchronous feedback" could include examples of a few labs in which a focus is placed on interaction with the students whose intent is to emphasize the dynamic nature of the scientific method. This ideally would involve instructors having direct verbal communication with students (could be interviews/office hours in which they talk about their data/hypothesis/proposed test or theoretical test they could perform) but may also include required written interaction in which the instructor is not simply grading the work but must provide feedback that the student acknowledges in some fashion (an iterative learning process). Again, they would not have to be this engaged in every laboratory, but it would be some component built into the scope of the course to provide this educational experience.

Natural Sciences Exemplars

Ohio Transfer 36 Natural Science Learning Outcome Exemplars

Below are examples of response to each of the eight learning outcomes. In some cases, examples from multiple disciplines are included. These are not meant to act as direct template for your course but rather to illustrate a range of formats and depth of response and elements of assessment and documentation that we hope to see to be able assess if your course fits well into the Ohio Transfer 36.

LO1: Understand the basic facts, principles, theories, and methods of modern science.
Example 1: Molecular Biology (lab course) A. Course Outcomes: The course outcomes, which can be found in the attached syllabus, include the following: 1) Illustrate the scientific method by analyzing significant biological discoveries. 2) Explain the process of inheritance, including genetic linkage and complex traits. 3) Understand various types of mutations and their effects on gene products and phenotype. 4) Describe the synthesis of RNA, DNA, and proteins. 5) Comprehend recombinant DNA technologies and their applications. 6) Explain the process of cell division in both somatic and germ cells. B. Assessments: Formative assessments: Pre-laboratory quizzes are administered for both previous and upcoming laboratory sessions. In-class worksheets (see examples in the attached Worksheet X) are provided in both the lab and the lecture. Summative assessments: Four formal exams are conducted throughout the semester, consisting of a combination of multiple-choice questions, short answers, and problem-solving. Additionally, in the laboratory, there are two formal lab write-ups and a final practical exam. C. Documentation: The following documents are provided: 1) An in-class worksheet (File: Worksheet X) allows students to demonstrate their understanding of basic facts, principles, theories, and methods of modern science. 2) Laboratory 2, titled "Mutation and Their Effects" (File: Lab2-Mutations), includes instructions for the formal lab write-up. 3) All laboratories are described in the “lab memo” document
Example 2: Chemistry A. Course Outcomes: In our course, we explore the foundational theory of atomic theory, which is discussed in Chapter 2 of the textbook. This theory posits that all matter consists of indivisible particles called atoms, composed of protons, neutrons, and electrons. For chemists, this concept holds immense significance as it forms the basis for understanding chemical reactions, physical properties, and energy. B and C. Assessment and Documentation: To assess students' comprehension of this foundational theory, we incorporate online homework assignments (See attached file X for an example) and

course exams. For instance, we may ask questions like, "How many protons, neutrons, and electrons are present in a neutral atom of carbon-14?" on our initial general chemistry exam.
Our practical laboratory component (see attached Lab syllabus and Lab Memo with descriptions of lab activities and LOs) is directly connected to the lecture material, allowing students to apply theoretical concepts in a hands-on setting. For example, when discussing the gas laws in lecture, we conduct a corresponding gas law experiment in the laboratory. We guide students in measuring the ideal gas constant using butane gas released from a lighter and collected over water. Through this experiment, they determine the ideal gas constant experimentally, which typically falls within 1% of the theoretical value utilized in our lecture's ideal gas equation.
By asking students to calculate an average gas constant in the lab and compare it to the value provided in lecture, we emphasize and evaluate their comprehension of one of the most fundamental and valuable theories in chemistry. This assessment approach allows us to gauge their understanding of the practical applications and limitations of the ideal gas law theory.

LO2: Explain how scientific principles are formulated, evaluated, and either modified or validated.

Example 1: Physical Geology virtual/distance lab course

A. Course Outcomes: Understand how hypotheses are generated, tested and modified if needed. Below are samples of labs that demonstrate and assess student learning of this outcome. Theory of Plate Tectonics: In this lab, students explore the theory of plate tectonics and the movement of the lithosphere. Using real-time earthquake data from reliable sources like the United States Geological Society, students examine earthquakes occurring daily, which vary in location, depth, and geological setting. As part of a specific assignment, they watch a video from IRIS (Incorporated Research Institutions for Seismology), answer questions, and collect recent earthquake data for a designated area.

B. Assessment: They analyze the depths and magnitudes of earthquakes and investigate possible correlations. By studying the variations in space and time, students discuss the principles of seismography, the importance of data interpolation, and potential challenges associated with interpreting seismic data. They are also presented with a series of seismographs to compare and identify natural variations. Furthermore, students employ satellite imagery, such as Google Earth and NASA remotely sensed data, to measure volcanic smoke plumes and generate spatial data. These measurements highlight natural variations between geographic areas and allow students to enhance their skills in interpreting satellite imagery.

Geologic Maps: In this lab students engage with provided geologic maps and utilize the Visible Geology App to create their own geological sequence. The instructor demonstrates the process synchronously, offering clear directions for students to follow. Each student then constructs their individual sequence, incorporating various principles of relative dating. They are required to produce a detailed report that both explains and deconstructs the information about environments of deposition, tectonic interactions, and the geological processes involved in their sequence's formation. As a challenging activity, students form groups and are assigned specific geological provinces or features, such as the Appalachian Mountain range.

B. Assessment: Their task is to evaluate the geological processes (orogeny), devise a plan, execute the model-building process using the computer application, and present their findings to the class through discussion boards or in-class discussions.

C. Documentation: These labs can be found as attached files (File X and File Y). The Lab Memo also shows how this learning outcome is addressed additional laboratory assignments and how criteria for virtual/distance lab activities are met.

Example 2: A short and generic response and therefore it is expected that there will be more supporting documentation including the syllabus should be more comprehensive and have Course and OT36 objected mapped to assignments.

A. Course outcomes: Describe how natural sciences can be used to explain and/or predict natural phenomena.

B. Assessment: All lab activities, whole-class activities, for example Science Knowledge Survey, Natural Selection; Dinosaurs and Extinction etc. are assessed on their learning outcome via performance on lab quizzes, exams, and lab activity worksheets.

C. Documentation: The lecture and lab syllabi list course objectives and how they correspond to the OT36 LOs. An in-class activity (File X), and example laboratory (File X) are provided. The Lab Memo describes which laboratories meet LO4.

LO3: Use current models and theories to describe, explain, or predict natural phenomena.

Example: Biology

A. Course Outcomes: The lecture component of the course will focus on current scientific knowledge, encompassing the models and theories used to explain and predict biological phenomena. This aligns with learning objectives #3, #4, and #5 as outlined in the syllabus.
In the laboratory activities, students will apply these current models and theories to make predictions about the outcomes of experiments. Each laboratory session includes at least one assignment to assess students' mastery of the material or provide feedback on any misconceptions they may have (formative assessment).

B. Assessment: To assess the understanding of these learning objectives, multiple exam questions will be dedicated to this topic. Particularly, the lab practical exam at the end of the semester will serve as the summative assessment for this specific learning objective.

C. Documentation: To illustrate the concepts and expectations, a sample lab (File X) and the lab practical (File X) have been provided as attachments.

LO4: Apply scientific methods of inquiry appropriate to the discipline to

gather data and draw evidence-based conclusions.

Example 1: Geology

A. Course Outcomes: This learning outcome is addressed in various ways throughout the course as it seeks to achieve this course outcome: Understand what it means to gather discipline appropriate data and draw evidence-based conclusions based on that data. Doing so includes both in-class and out-of- class exercises. Alongside required readings and interactive lectures, students engage in a series of activities that contribute to their understanding of the scientific method and its application in Earth- related disciplines. Specifically, the following areas and exercises are designed to address this
outcome:

- Nature of Science - Hutchinson Gas Explosion exercise
- Asteroids - Nibiru analysis exercise
- Plate Tectonics - merging geophysical data exercise
- Earthquakes - hazard assessment exercise
- Volcanoes - hazard assessment exercise
- Rocks and Minerals - rock identification in class
- Geologic Time - fossil analysis in class
- Streams - flood recurrence exercise
- Oceans - coastal erosion exercise
- Atmosphere - wind prediction exercise
- Weather - weather forecasting exercise
- Global Change - future climate modeling exercise

B: Assessment: To assess student understanding, in-class exercises are periodically collected and graded. Students also encounter mastery-based multiple-choice questions on weekly chapter quizzes, where they must analyze and evaluate their knowledge. Similar types of questions, including multiple- choice, matching, and multi-select, are included in four summative exams and the final exam. Additionally, students are required to develop action plans for hazard scenarios.

C: Documentation: For more details on specific graded exercises, quiz and exam requirements, please refer to the attached "assignments" page. The Geological Time exercise is a notable example directly linked to LO4

Example 2: Chemistry – Short with reference to mapping done in the syllabus

A. Course Objectives: 1) Learn what disciplinary-specific data can be collected and how, and Understand how conclusions are drawn from data. Although this course does not involve direct data collection by students, they actively engage in interpreting data and drawing evidence-based conclusions across various topics.

B: Assessment: One notable area is reaction rates, where students analyze changes in concentration over time in chemical reactions to gain insights into reaction rates. Additionally, through problem-solving exercises in acid-base chemistry, students develop an understanding of the relationship between pH and the concentrations of acid and conjugate base species in solution. These activities empower students to apply their knowledge and make informed interpretations based on the data provided.

C: Documentation: See syllabus to see mapping of LO4 to various lectures. See attachment X for an example of this in practice.

Example 3: Physical Geography (Note: Virtual/distance and also addressed LO5)

A. Course Outcome: Understand what it means to gather discipline appropriate data and draw evidence-based conclusions based on that data. Students will participate in a semester-long weather project aimed at enhancing their understanding of weather data. The project entails keeping a weather journal for two distinct locations over several consecutive weeks (see attached file XX providing instructions and grading rubric). The primary objective is to familiarize students with weather data and enable them to access real-time measurements through online sources. Students will be responsible for collecting weather data consistently throughout the designated period and subsequently analyzing it.

To fulfill this assignment, students will need to input their collected data into Microsoft Excel. They will then utilize this software to generate bar graphs and tables, which will serve to visually represent their findings in the results and analysis section of their written paper. It is important to note that while the assignment remains the same for all students, those enrolled in the virtual/distance lab component will be required to collect temperature and precipitation data using a thermometer and rain gauge at their respective residences.

B. Assessment: This semester-long project will culminate in a comprehensive write-up and analysis of the gathered results, demonstrating the application of scientific inquiry. In addition, students will be given access to a pool of other student data allowing for an exploration of the amount of variation and discussion of the factors that resulted in such variation to exist. Students will be expected to submit weekly written reports, further strengthening their scientific skills and documentation abilities.

C. Documentation: The project directions, worksheets and grading rubric are provided in a single attached file (File X).

LO5: Demonstrate an understanding that scientific data must be reproducible but that it shows intrinsic variation and can have limitations.

Example: Astronomy

A. Course Outcomes: The main focus of the course is on three fundamental questions: What do we know? How do we know it? Why should we believe it? These questions guide every topic covered in the course, emphasizing the importance of critical thinking and the provisional nature of scientific knowledge.

Throughout the course, students learn that the second and third questions are particularly significant, as science continually seeks to refine and expand our understanding. Students are consistently reminded about the gaps, uncertainties, and limitations inherent in our knowledge.

B. Assessment: To further develop their understanding, students are assigned homework that involves working through a Mastering Astronomy tutorial called "The Process of Science: Identifying

Falsifiable Statements". The tutorial focuses on the concept that scientific models must make predictions that can be tested through observations or experiments. Students are presented with historical statements and scientific statements and asked to determine which ones are falsifiable and which ones are not. By engaging in these activities, students are encouraged to critically evaluate scientific claims and understand the importance of falsifiability in scientific inquiry. This approach fosters a deeper appreciation for the provisional nature of scientific knowledge and the ongoing process of scientific exploration and discovery. C. Documentation: In addition to course objectives, expectations and content delivery schedule found in the syllabus please find a copy of the homework assignment (File XX) mentioned above which includes objectives, directions, and a grading rubric.
Example 2: Biology A. Course Outcomes: Learn how work with scientific data. In the laboratory, students conduct experiments repeatedly under controlled conditions. They carefully analyze and compare the results obtained from these repeated trials, taking note of any differences while observing the overall similarity. Emphasis is placed on understanding the sources of uncertainty in measurements, and students are required to justify variations in the data by considering a list of potential causes of uncertainty that they identify. (see lab X as a supplemental file). During lecture demonstrations, uncertainties and occasional failures are acknowledged, but the belief in the reproducibility of experiments typically persists, leading to successful outcomes. B. Assessment: Lab reports involve discussion and recommendations of practical approaches to minimize existing uncertainties, demonstrating the students' understanding of the importance of reducing measurement errors. There are several exam questions requiring students to showthey understand the importance of significant figures and sources of variation in scientific data. C. Documentation: Labs X, Y and Z address this LO directions (see lab memo for details).
Example 3: Chemistry A. Course Outcome: Understand the nature of scientific data including its reproducibility and variability. Students understand the reliability of a measurement by learning about precision, accuracy, and how to report and average and standard deviation. Students understand that all measurements have some degree of uncertainty and that the last digit in a measurement is estimated. Students learn how to determine the number of significant figures after calculations. B. Assessment: Students are assessed on these learning outcomes via exams, homework assignments through the textbook publishers software package, lab experiment performance, and lab write-ups. C. Documentation: Syllabus provides evidence of exams and the topics they cover. Homework assignments X, X and X address this LO and homework assignment X is provided as an attachment. The lab memo summarizes the activities of the labs and identifies which ones address this LO.

LO6: Apply foundational knowledge and discipline-specific concepts to address issues or solve problems.

Example 1: Chemistry

A. Course Outcomes: Throughout the course, students are consistently challenged to apply the principles they learn to solve a variety of quantitative and conceptual problems. In every section of the course, students also witness the direct relevance of the chemical principles they study to significant contemporary issues. Particularly, they explore the connection between these principles and crucial topics such as environmental concerns (e.g., air and water pollution, carbon footprint resulting from fossil fuel combustion, acid rain, ocean acidification), energy, and pharmaceuticals. By recognizing these connections, students gain a deeper understanding of the real-world implications of the chemical concepts they encounter and develop a broader awareness of the role chemistry plays in addressing pressing global challenges.

B and C. Assessment and Documentation: These problem-solving skills are actively developed through assigned homework sets (see homework X provided as a supplemental file and descriptions of homework assignment in the working syllabus for the course), which predominantly consist of such problems. Additionally, each exam presents students with numerous quantitative and conceptual problems that require their application of the learned principles.

Example 2: Biology and Technology

A. Course Outcomes: In the contemporary world, various complex challenges have emerged as a result of human activities, encompassing concerns such as environmental pollution, climate change, food scarcity, disease outbreaks, misinformation and disinformation, and human health. Throughout the semester, students are introduced to a range of biotechnology applications that tackle these issues by employing foundational knowledge and specific concepts in biotechnology.

The exploration of these issues and applications predominantly occurs in the second half of the semester, spanning Lectures 16 to 26. This follows the students' acquisition of fundamental knowledge in molecular biology, genetics, and biotechnologies during the initial half of the semester (Lectures 1 to 14). For instance, during the "Plant Transformation" lecture, the impact of Bt corn on the monarch butterfly population is discussed as an illustrative example, emphasizing the significance of scientific understanding in the context of biotechnology products.

In the "Microbial Biotechnology" lecture (Lecture X), various topics such as recombinant insulin drugs, mRNA vaccines, and genetically modified chymosin for cheese production are explored to showcase the role of biotechnology in enhancing human health and food production. The concept of post- translational modification is introduced in "Animal Biotechnology" (Lecture X) to underscore its importance in developing effective recombinant drugs. Moreover, Team Activity X (see attached supplemental file named X) stimulates debates on the impact of livestock agriculture on climate change, allowing students to delve into the complexities of the subject.

B. Assessment: To assess students' comprehension of how biotechnology concepts can be applied to address issues and solve problems, debates are conducted on topics such as crop genetic engineering, livestock agriculture, forensic anthropology, and human genetic engineering.

Additionally, mid-term exams provide further evaluation of students' understanding in this regard. By engaging with these activities and assessments, students gain a deeper understanding of how biotechnology can be harnessed to tackle critical contemporary challenges.

C. Documentation (See notes in A)

LO7: Explain how scientific principles are used in understanding the modern world, and understand the impact of science on the contemporary world.

Example 1: Climate and the Environment

A. Course Outcomes: Appy scientific principles to understanding contemporary problems. In response to the Atlantic article titled "How a Plan to Save the Power System Disappeared," students engage in discussions analyzing the content and implications of the article. The article shed light a local geothermal plant, prompting further discussions among the students about the benefits and challenges associated with such projects.

B and C. Assessment and Documentation: To delve deeper into the topic, an assignment was given to students (File X attached which provides directions and grading rubric), requiring them to research and present information on Renewable Portfolio Standards, Feed-in Tariffs, or other incentives applicable to their home state or country. This assignment encourages students to share their opinions on whether governments should regulate the extent of renewable energy usage.

In addition, discussion posts (see writing prompt provided in the syllabus) provided a platform for students to share arguments they had encountered against climate change. These discussions encouraged students to critically evaluate these arguments and engage in constructive dialogue. Similarly, students also explored potential solutions to mitigate or reverse climate change in discussion posts, fostering an environment for brainstorming and sharing actionable ideas.

Example 2: Geoscience Distance/On-line lab course

A. Course Outcomes: Appy scientific principles to understanding problems in geosciences that effect our everyday lives. The course integrates the science of plate tectonic theory, tracing its history from the scientific revolution to its contemporary study. Emphasizing the interconnected nature of geology in everyday life, multiple sections of the course highlight its relevance. Here are two specific examples of labs that utilize real-life data:

Lab X (see attached file X): In this lab students determine porosity by calculating the ratio of dry mass to wet mass using digital scales. They compare the porosity of two different rock types to their respective grain characteristics and calculate the percentage of porosity based on the collected data. This analysis extends to a real-life case study of the Ogallala Aquifer and the ongoing monitoring of the Great Lakes. Throughout the lab, students record their progress, and the instructor provides real-time guidance and support. The impact of scientific monitoring on social events, such as beach closings in Lake Erie, is explored, fostering discussions on the implications of water quality for human life and recreation.

Lab X (see attached file X): In this lab students identify fluvial landforms using topographic maps and satellite images. Each student is assigned a unique geographical study area, such as the Amazon River basin, the Mississippi River, or the Cuyahoga River. They learn to observe and interpret remote sensing data, including oblique aerial photos and satellite imagery. Additionally, students calculate the gradient of their assigned river/study area and create topographic/elevation profiles. Historical satellite imagery/data is utilized to analyze the evolution of meanders in rivers over time, which is demonstrated by the instructor. Moreover, students explore near real-time river gages provided by the USGS, observing changes in gage height throughout the semester. The instructor also employs a stream table, similar to a model, with different sediment sizes to simulate water flow, allowing students to identify features based on water flow, sediment sizes, deposition rates, and discharge.

B. Assessment: Lab reports and short answer exam questions

C. Documentation: See Lab Memo for details of all labs and notes as to which of these address this LO. Labs X and X are provided as examples.

Example 3: Genetics

A. Course Outcomes: Know how genetics can help us understand human genetic disorders. In the "Tracing Genetic Disorders" assignment, students engage in practicing techniques derived from classical genetics that are commonly used in genetic counseling (see attached file XXX). The concept of the cell cycle, introduced while exploring reproduction at the cellular level, is explored by students who then apply this knowledge to the study of cancer. During class sessions, we delve into the scientific discovery of protooncogenes and tumor suppressor genes, which have greatly contributed to our understanding of cancer development. This understanding is further enhanced through the study of molecular genetics, as covered in Chapter X on Molecular Biology. By employing molecular genetics, scientists can now identify early mutations that serve as risk factors for developing certain cancers.

B and C. Assessment and Documentation: To reinforce and assess these concepts, we discuss the emergence of different treatment approaches that have been developed based on this knowledge. Lastly this becomes the basis for online discussion forums (see syllabus for writing prompt and grading rubric), fostering interactive engagement among students

LO8: Gather, comprehend, apply and communicate credible information on scientific topics, evaluate evidence-based scientific arguments in a logical fashion, and distinguish between scientific and non-scientific evidence and explanations.

Example 1: Human Biology

A. Course Outcomes: Course learning objectives #1 and #2, as outlined in the syllabus, encompass this particular topic. The Human Health Project has been specifically designed to facilitate student engagement in this area. The project requires students to select a topic, gather reliable information by critically evaluating scientific evidence, and present their findings through a written paper and oral presentation. As part of the project, students are tasked with evaluating a popular science article relevant to their chosen topic, as well as locating credible primary and review articles from

reputable scientific journals and other reliable sources. To assist students in this process, an early lecture is dedicated to exploring various forms of scientific communication, criteria for assessing credibility, and concepts such as bias and sound experimental design. Additionally, through discussions on New York Times article XX, students will gain practical experience in working with and identifying credible information sources. B. Assessment: The early assignments within the Human Health Project serve as formative assessments, while the final paper and presentation serve as summative assessments. C. Documentation: See file X attached which includes the directions and grading rubric for the Human Health Project.
Example 2: Geology (lecture only course) A. Course Outcomes: Student will be able to distinguish between scientific and non-scientific explanations for natural phenomena. Prior to class, students are assigned reading materials, and they participate in interactive lectures that incorporate conceptual questions. This learning outcome is addressed for each topic covered in the course. For example, in Chapter 1, students evaluate scenarios representing "good" and "bad" science. In Chapter X, they assess old and new ideas concerning Earth's origin and orbit. In Chapter X, they compare continental drift to plate tectonics. In Chapter X, they evaluate explanations for the age of the Earth from both faith-based and science-based perspectives. In Chapter X, students examine scientific evidence related to climate change and compare it to arguments presented by climate change deniers. B and C. Assessment and Documentation: Alongside required readings and interactive lectures, students complete a series of exercises inside and outside of class specifically designed to address this learning outcome. These exercises align with the respective topic areas mentioned above. Additionally, these topics are assessed in exams. Detailed information about graded exercises, quizzes, and exam requirements can be found on the attached "assignments" document.