Illinois State University
Department of Chemistry
CHE 402.01
Teaching Chemistry in the Laboratory: An Experimental Science
3 credit hours

Catalog Description

Topical analysis of current best practices in teaching chemistry as an experimental science as it can be achieved in secondary school classrooms. A particular emphasis will be to connect content knowledge to modern demonstrations, experiments, and teaching activities.

Instructor: Dr. Sarah Boesdorfer
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Online Zoom Office Hours: By appointment any time.

Required Materials

Required: Access to the Canvas Course Website

Required: Teaching Chemistry as an Experimental Science Videos (https://www.flinnsci.com/teaching-experimental-science/che402.01)

Contact Hours:

This course is a structured, asynchronous course available online for 8 *(summer term)* or 16 *(fall/spring term)* weeks from the start date of the course. Each assignment, except the discussion and final project, will be available at the start of the course but will have specific deadlines for when they need to be completed.

Accommodations:

Any student needing to arrange a reasonable accommodation for a documented disability and/or medical/mental health condition should contact Student Access and Accommodation Services at 308 Fell Hall, Office Phone (309) 438-5853, Video Phone (309) 319-7682 or visit the website at StudentAccess.IllinoisState.edu.

Course Structure, Overview, and Objectives

This course constitutes a survey course of ways in which we can understand and teach chemistry as an experimental science. A particular emphasis will be to connect content knowledge to modern demonstrations, experiments and teaching activities. Students will improve their chemistry content knowledge from the resource materials, as well as be expected to search local and internet-based resources for current best practices. Students will be introduced to demonstrations, experiments and teaching activities which engage them in a detailed examination of the ways in which current chemistry teachers use experimentation as a central part of their teaching. Students will be exposed to and expected to master the demonstration activities taught in the course.

This course is structured into six learning modules according to topic:

1) Introduction to Chemistry as an Experimental Science - This module reminds you of some basic learning theory, pedagogy, and how it applies to teaching chemistry.
2) Nature of Science, Science and Engineering Practices, Misconceptions, and Discrepant Events in Chemistry - In this section of the course, we will look at issues surrounding students' misconceptions and the use of discrepant events or other methods to confront those misconceptions, along with ways of incorporating science and engineering practices and nature of science learning into the chemistry classroom.
3) Inquiry in Chemistry - In this section of the course, we will look at ways to incorporate inquiry and inquiry learning in the chemistry classroom.
4) Teaching Strategies for the Chemistry Classroom - During this section of the course, we will examine some different teaching strategies that might be used when teaching chemistry including the use of toys in the classroom, silent demonstrations, analogies, pogil, Claims, Evidence Reasoning, and modeling among others.
5) Expanding our Definition of Laboratory Assignments - In this section of the course, we will look at some different ways that we have not mentioned yet to challenge students in the chemistry classroom and lab including virtual laboratory experiments or at home experiments.
6) Technology in the Chemistry Classroom - In this final section of the course, we will explore technologies that can be used to support learning in the classroom, including how to use technologies effectively to promote and improve learning for all students.

This course seeks to provide some answers to the following questions:

1. What is our current best understanding of the traditional and modern scientific method?
2. What are the safety considerations and risks associated with teaching chemistry demonstrations and experiments? How may chemistry be taught safely in schools?
3. What is the role of the National Standards and State Standards in determining what scientific and chemistry process skills are taught in schools?
4. What pedagogical techniques are appropriate for teaching students to conduct experiments in secondary schools?
5. What are the challenges associated with teaching the experimental nature of chemistry and science?
6. How can technology be used to teach chemistry effectively as an experimental science?

Description of Assignments/Expectations

1) Module Quizzes – *Most* modules include a quiz covers the articles and/or videos assigned for that module. Quizzes consist of content specific and pedagogical questions. The lowest order (Knowledge and Comprehension) of the questions are designed to ensure that students watch the video. The medium-order (Analysis and Application) and higher-order (Synthesis and Evaluation) questions may require the use of outside resources to generate correct answers or to consider the use of activity in their own classroom to determine the correct answer. *A quiz is considered passed and meeting expectations when a 90% or better is received.* A student may retake the quiz as many times as they like through the due date to achieve the 90% or better.

2) Discussion Posts – Modules 1, 2, 3, and 5 contain a prompt for groups of 5-6 students to discuss. Posts are generally 100-200 words in length, and should use supporting information drawn from the articles and videos in that module. Students are also required to post at least three responses to their group members' posts that are thoughtful and constructive of the original post. Responses can be shorter and are generally 50-100

words in length. Students must participate as described in both the initial post and responses, by the posted due dates to meet expectations for each discussion.

3) 'Research' Presentations with Peer Review – Modules 4 and 6 contain a research presentation which will be commented on by your peers. The recorded presentations focus on finding more information about a specific teaching approach or technology in the classroom that is of interest to you. A complete description of expectations for the presentation and peer comments is provided on Canvas.

4) Final Project – Teaching Methods Paper and Reflection
Students will be asked to write essay about three teaching methods learned throughout the course and reflect on what they have learned from others. A full description and rubric will be provided in Canvas.

5) Professionalism: You are expected to
   - Be positive, patient, and approachable.
   - Work hard- be effective and efficient when assuming responsibilities.
   - Work collaboratively with your peers and educational professionals.
   - Be respectful to your peers, professionals, and students.
   - Be open to advice and suggestions from peers and professionals.
   - Be punctual- Complete assigned tasks on time.

Course Evaluation:

Canvas will be used to post whether an assignment or task has Met Expectations (1 / 1) or Not Met Expectations (0/1) with the exception of quizzes which require a 90% or better to meet expectations.

To receive **an A** in this course a student will:

- Actively participate in the course by meeting expectations for all quizzes and discussions, though up to one may not meet expectations.
- Meet Expectations as Peer Reviewer/Commentator on both "Research Presentations'
- Create two Research Presentations which meets expectations in all categories from the rubric.
- Create Final Project which meets expectations in all categories from the rubric.
- Display all aspects of professionalism throughout the course.

To receive **a B** in this course a student will:

- Actively participate in the course by meeting expectations for all quizzes and discussions, though up to one may not meet expectations.
- Struggle in <u>one</u> of the following areas:
  - Meet Expectations as Peer Reviewer/Commentator on both "Research Presentations'
  - Create two Research Presentations which meets expectations in all categories from the rubric.
  - Create Final Project which meets expectations in all categories from the rubric.
  - Display all aspects of professionalism throughout the course.

To receive **a C** in this course, a student will:

- Struggle in <u>two</u> of the following areas:

- Actively participate in the course by meeting expectations for all quizzes and discussions, though up to one may not meet expectations. [At least 7 out of 10 must be at meets expectations level]
- Meet Expectations as Peer Reviewer/Commentator on both "Research Presentations'
- Create two Research Presentations which meets expectations in all categories from the rubric.
- Create Final Project which meets expectations in all categories from the rubric.
- Display all aspects of professionalism throughout the course.

To receive a **D** in this course a student will:

- Struggle in <u>three</u> of the following areas:
  - Actively participate in the course by meeting expectations for all quizzes and discussions, though up to one may not meet expectations. [At least 6 out of 10 must be at meets expectations level]
  - Meet Expectations as Peer Reviewer/Commentator on both "Research Presentations'
  - Create two Research Presentations which meets expectations in all categories from the rubric.
  - Create Final Project which meets expectations in all categories from the rubric.
  - Display all aspects of professionalism throughout the course.

To receive an **F** in this course a student will:

- Fail to meet the requirements to receive a D.

<u>AND/OR</u>

- Participation in the course through quizzes and discussions is 50% or less at met expectations level, no matter what other course work.

Course Deadlines – Fall 2025

Please note that all assignments are due 11:59 PM CST on the date shown. If you are in a different time zone, please plan accordingly.

	Due Date	**Assignment Due**
Semester Starts	**Mon Aug 18**	
Week 1	Fri Aug 22	Module 1 Quiz Module 1 Discussion Post
Week 2	Wed Aug 27 Fri Aug 29	Module 1 Discussion Response Module 2 Quiz
Week 3	Wed Sept 3	Module 2 Discussion Post
Week 4	Mon Sept 8 Fri Sept 12	Module 2 Discussion Response Module 3 Quiz
Week 5	Fri Sept 19	Module 3 Discussion Post
Week 6	Wed Sept 24	Module 3 Discussion Response
Week 7	Fri Oct 3	Module 4 Discussion Post
Week 8	Mon Oct 6	Module 4 Research Presentation Posted
Week 9	Mon Oct 13 Fri Oct 17	Module 4 Peer Comments on Presentations Module 5 Quiz
Week 10	Wed Oct 22	Module 5 Discussion Post
Week 11	Wed Oct 29	Module 5 Discussion Response
Week 12	Mon Nov 3 Fri Nov 7	Module 6 Discussion Starts Module 6 Discussion Response
Week 13	Fri Nov 14	Module 6 Research Presentation Posted
Week 14	Fri Nov 21	Module 6 Peer Comments on Presentations
Week 15		**Thanksgiving Break**
Week 16	Wed Dec 3	Final Project Due
Finals Week		If resubmission of final paper needed-submitted by Fri Dec 12

Learning Modules: Checklist of Assigned Articles, Videos, and Assignments

Module 1: Introduction to Chemistry as an Experimental Science

- ☐ Article: Constructivism: A Theory of Knowledge
- ☐ Article: Expanding the 5E Model
- ☐ Article: Straw Men and False Dichotomies: Overcoming Philosophical Confusion in Chemical Education
- ☐ Article: Chemistry in Past and New Science Frameworks and Standards: Gains, Losses, and Missed Opportunities
- ☐ Video Package: Scientific Method / Critical Thinking and Problem Solving
    - Playing With Words
- ☐ Module Quiz
- ☐ Module Discussion

Module 2: Nature of Science, Science and Engineering Practices, Misconceptions, and Discrepant Events in Chemistry

- ☐ Article: Science for All Americans, Chapter 1
- ☐ Article: The Big Freeze: Water and the Scientific Process
- ☐ Article: High-Impact Strategies for Implementing Next Generation Science Standards
- ☐ Article: Using the Socioscientific Context of Climate Change To Teach Chemical Content and the Nature of Science
- ☐ Article: Teaching to Achieve Conceptual Change
- ☐ Article: An Inventory for Alternate Conceptions among First-Semester General Chemistry Students
- ☐ Module Quiz over Articles

You will choose 2 Packages

- ☐ Video Package: Scientific Method / Observation Skills
    - Foiled Again
    - The Potato Candle
    - Goldenrod Messages and Name Tags
    - Flask and Tubing Observation Activity
- ☐ Video Package: Scientific Method / Scientific Method Demonstrations
    - Paraffin Paradox
    - Think Tube
- ☐ Video Package: There's Magic in Chemistry
    - Accuracy and Precision Card Trick
    - Ropes and Isotopes
    - Intermolecular Forces Magic Trick
    - The Mellow-Yellow Reaction
    - Magic of Teaching
- ☐ Video Package: Teaching Strategies / Discrepant Event—Physical Properties
    - The Disappearing Beaker
    - Surface Tension Demonstration
    - Indicator Sponge
    - On the Level
    - Ice Melting Blocks
- ☐ Video Package: Teaching Strategies / Discrepant Event—Classroom Lessons
    - Mass vs. Density

- Discrepant Balloons
- Preparation of Discrepant Balloons
- Needle in a Balloon

☐ Module Discussion- Videos and how to use in class.

Module 3: Inquiry in Chemistry

☐ Article: Inquiry Learning: What Is It? How Do You Do It?
☐ Article: Preparing Students To Benefit from Inquiry-Based Activities in the Chemistry Laboratory: Guidelines and Suggestions
☐ Video Package: Scientific Method / Scientific Method Demonstrations
- Reaction in a Bag

☐ Video Package: Inquiry Labs / Using Demonstrations to Promote Inquiry
- Electrochemical Clock
- Iodine Clock Challenge
- Rolling Spheres Down an Inclined Plane

☐ Video Package: Inquiry Labs / Inquiry Lab Activities
- Flinking - Neither Floating nor Sinking?
- Mystery Solutions Lab
- Average or Apparent Mass of an Element
- Analysis of Unknown Solids

☐ Module Quiz
☐ Module Discussion

Module 4: Teaching Strategies for the Chemistry Classroom

You <u>will pick one</u> of the following for the Module Discussion:
☐ Article: The Effect of Using Concept Maps as Study Tools on Achievement in Chemistry
☐ Article: The role of student-generated analogies in promoting conceptual understanding for undergraduate chemistry students
☐ Video Package: Scientific Method / Critical Thinking and Problem Solving <u>AND</u> Video Package: Teaching Strategies / Silent Demonstrations
- Lota Bowl
- Silent Lecture
- Penney's Quick Silent Demos

☐ Video Package: Teaching Strategies / Teaching With Toys
- Hand Blasters
- Ralphie, the Drinking Bird
- Circle of Hand

☐ Video Package: Teaching Strategies / Momentary Diversions
- Equilibrium Arrow
- Bunsen's Birthday
- Mirror Glass

☐ 'Research' Presentations (**you will <u>just pick one</u>**)
1. POGIL [Article: Chapter 7 POGIL: Process-Oriented Guided Inquiry Learning]
2. Modeling [Article: Applying Modeling Instruction to High School Chemistry To Improve Students' Conceptual Understanding]
3. Claims, Evidence, Reasoning Approach [Article: Implementing the Claim, Evidence, Reasoning Framework in the Chemistry Classroom]

4. Simulations (PhET, Concord Chem, etc.) [Article: Computer Simulations to Support Science Instruction and Learning: A critical review of the literature]
5. Argument Driven Inquiry [Article: Argument-Driven Inquiry as a way to help undergraduate students write to learn by learning to write in chemistry]
6. 3-D Assessment Strategies [Article: Adapting Assessment Tasks To Support Three-Dimensional Learning]

Module 5: Expanding our Definition of Laboratory Assignments

- ☐ Article: Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research
- ☐ Article: Student learning in science simulations: Design features that promote learning gains
- ☐ Article: Take Home Labs: Making Science Real (Pre-Covid, March 2017)
- ☐ Article: Creative Ways to Conduct Traditional Labs in a Homeschool Environment (Nov 2020)
- ☐ Video Package: Inquiry Labs / Bob Becker Target Labs
    - Target Lab Discussion
    - Target Density Lab
    - Target Stoichiometry Lab
    - Target Mole Lab
    - Target Gas Law Lab
- ☐ Video Package: Inquiry Labs / Jeff Bracken Challenge Labs
    - Measurement Challenge
    - Test Tube Challenge
    - MSDS Challenge Inquiry Lab
    - Production of Sodium Carbonate Lab
- ☐ Module Quiz
- ☐ Module Discussion.

Module 6: Technology in the Chemistry Classroom

- ☐ Article: Ways to Use Tech in the Classroom
- ☐ Article: Incorporating Technology Tools and the 5E Instructional Model to Teach High School Students Chemistry by Online Instruction
- ☐ Article: Conclusion: Technology Integration in Chemistry Education and Research: What Did We Learn and What Can We Expect Going Forward?
- ☐ Module Discussion
- ☐ Research Presentation: **You will pick 1**. Possible topics include (but may ask for approval for others):
    - Nearpod/Peardeck- (these are VERY similar platforms so grouped together)
    - Virtual Notebooks
    - "Games" – Kahoot, Quizzez etc.
    - Whiteboards/Jamboard/Padlets- Collaboration software in real time
    - Flipgrid (or type)
    - Learning from videos (EdPuzzle etc.)