Modeling Instruction in High School Chemistry
(2 Week AMTA Workshop)
EDUO 9563 : 1 – 4 Graduate-Level Credits

Course Overview:

Chemistry: Modeling Instruction is designed to provide secondary chemistry teachers with the tools, experiences, and background needed to improve their chemistry instruction using a proven and award-winning methodology known as Modeling.

Course Description:

The main objective of the course is to acquaint teachers with all aspects of Modeling Instruction and develop some skill in implementing it. To that end, teachers are provided with a fairly complete set of written curriculum materials to support instruction organized into coherent modeling cycles. The physical materials and experiments in the curriculum are simple and quite standard, already available in any reasonably-equipped chemistry classroom.

The goal of this Modeling Method course is to provide a meaningful form of professional development for pre-service or in-service teachers using student-centered, inquiry-based, constructivist practices. Participants will frequently be asked to play two roles. First, they will be asked to take the role of a novice student in chemistry (similar to their actual students) as they perform all the laboratory investigations and problem solving that such students will be asked to do. Armed with a taxonomy of common preconceptions and misconceptions students hold will give participants a useful perspective from which they will be better able to address their own student’s learning obstacles. Second, they will be asked to play the role of the classroom chemistry teacher where they will be able to practice the techniques of managing student discourse, using Socratic dialogue, and general classroom management in an inquiry-based classroom. Throughout the course, teachers are asked to reflect on their practice and how they might apply the techniques they have learned in the course to their own classes. The principles learned here can be readily transferred to any other sort of classroom instruction.
Modeling Instruction is a research-based reformed pedagogy that is the only high school science program recognized as Exemplary by the U.S. Department of Education. Modeling instruction addresses many weaknesses of the traditional lecture-demonstration method, including fragmentation of knowledge, student passivity and persistence of naive beliefs about the physical world. Unlike the traditional approach, in which students wade through an endless stream of seemingly unrelated topics, Modeling Instruction organizes the course around a small number of scientific models, thus helping students become better thinkers about the core concepts in chemistry. It applies structured inquiry techniques to the teaching of basic skills and practices in mathematical modeling, proportional reasoning, quantitative estimation and technology-enabled data collection and analysis. In Modeling classrooms, students observe, analyze, draw conclusions, then propose and evaluate models using representations and take part in productive conversations about the science being learned. The approach is entirely consistent with the NGSS Science and Engineering Practices and Ohio Science Standards.

Course Objectives: NGSS Content & Teaching Standards Addressed
As a result of this course, the participant will be able to:

- Comprehend and implement a model-centered, guided inquiry method of teaching high school chemistry.
- Integrate computer courseware effectively into the chemistry curriculum.
- Utilize an electronic network support and a learning community among participants.
- Strengthen local institutional support for participants as school leaders in disseminating standards-based reform in science education.

Course Relation to NGSS Content & Teaching Standards:

**NGSS Science and Engineering Practices**
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**NGSS Disciplinary Core Ideas**

**HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

**HS-PS1-4.** Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

**HS-PS1-5.** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

**HS-PS1-7.** Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

**HS-PS3-1.** Create a computational model to calculate the change in the energy of one
component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

Course Assignments & Required Content:

Unit 1: Physical Properties of Matter – The Particle Model
Unit 2: Energy and States of Matter – Part 1
Unit 2: Energy and States of Matter – Part 2
Unit 4: Describing Substances
Unit 5: Counting Particles Too Small to See
Unit 6: Particles with Internal Structure
Unit 7: Chemical Reactions: Particles and Energy
Unit 8: Stoichiometry – Part 1

Class Assignments
Teachers are expected to do the following:

- Complete the Assessment of Basic Chemistry Concepts (ABCC) pre-test on the first day of class. This will set a base score for each participant.

- Keep a course notebook in which you record notes in both “student” and “teacher” modes. In “student mode”, you will be expected to record notes from the pre-lab discussion, record and evaluate data, and summarize the findings of the “class” as if you were a student in your course. In “teacher mode”, you should record hints that will help when you have students perform labs, questions to ask during whiteboarding, and suggestions about demonstrations and the concept they are meant to illustrate. Teachers find this notebook to be a valuable resource as they use the curricular materials in their own classes.

- Write and submit short (1-2 pp.) “unit reflections” on each of the units. These reflections are expected to articulate an evolving understanding of Modeling Instruction in chemistry.

- Participate actively and thoughtfully in lab whiteboarding sessions, discussion of readings, activities, and problem-solving whiteboarding.

- Read excerpts from chemical education research articles as assigned and participate in subsequent discussions.

- No later than the final day of class, write and submit a final paper (at least 4 pages, double-spaced, 12 point font) demonstrating further evolution in your capacity to implement and enact chemistry modeling instruction methods in your classroom. You should focus on specific,
content-related practices that have direct applicability in the classroom, and avoid empty
generalities. The use and inclusion of “multiple representations” (as explained, demonstrated
and promoted in the workshop) is encouraged wherever appropriate. You may wish to focus
on one or more of the following questions:

a) How can Modeling Instruction be implemented in your classroom? In particular, how
could one or more of the teaching units in this workshop be used in your specific teaching
situation? For example, to utilize a specific type of equipment available at your school, to
focus on a particular reasoning skill, or to improve one or more of your own existing,
successful classroom activities by incorporating some aspect(s) of Modeling Instruction.

b) Contrast the classroom procedures used in the modeling pedagogy with those typically
used in a conventional teaching approach.

c) In what ways and to what extent does a non-modeling reformed pedagogy (like POGIL
or Target Inquiry) differ from Modeling Instruction? Is it more inquiry-based than
modeling? Less inquiry based? This should be supported with examples, quotes from the
materials, or other evidence

**Text and Required Reading:**

The articles listed here will be provided electronically to the teachers.


Course Assessment Rubrics

Final grades will be based on the following point totals and percentages:

- **A**: 90-100% (270-300 points total)
- **B**: 80-89% (240-269 points total)
- **C**: 70-79% (210-239 points total)

### Assignment #1: Keep a course notebook. (60 points: 20% of course grade)

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<thead>
<tr>
<th>54-60 points</th>
<th>48-52 points</th>
<th>42-46 points</th>
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<tr>
<td>Participant records clear, focused comments and notes on how each lab and problem set is viewed from both the student and teacher perspectives. Entries include many additional suggestions for implementation, changes, and questions for Socratic Dialogue and class discussion.</td>
<td>Participant records general comments and notes on how each lab and problem set is viewed from both the student and teacher perspectives. Entries include a few suggestions for class discussion.</td>
<td>Participant records comments on how each lab and problem set is viewed from one of either the student or teacher’s perspective.</td>
<td>Participant does not consistently record comments or notes about classroom activities.</td>
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### Assignment #2: Keep a reflection journal (60 points: 20% of course grade)

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<tr>
<th>54-60 points</th>
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<td>Participant records a clear, focused reflection about each unit covered, including thoughts on how the model has evolved based on the evidence collected. Entries include many additional suggestions for implementation, changes, and questions for Socratic dialogue and class discussion.</td>
<td>Participant records a general reflection about each unit covered, considering both the student and teacher perspectives. Entries include a few suggestions for class discussion.</td>
<td>Participant records reasonable reflections for a majority but not all of the units or from one of either the student or teacher’s perspective.</td>
<td>Participant records few or no reasonable attempts on unit reflections.</td>
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### Assignment #3: Participate actively and thoughtfully in lab whiteboarding sessions, discussion of readings, activities, and problem-solving whiteboarding. (90 points: 30% of course grade)

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<tr>
<td>Is a prompt and regular attendant; stays until the completion of the session; participates in group activities and discussion by asking questions and offering ideas during whiteboarding</td>
<td>Is a prompt and regular attendant; arrives late or leaves early only with the prior notification of the instructor; participates in group activities and discussion by asking questions and offering ideas during whiteboarding</td>
<td>Is usually but not always prompt and regular attendant; participates most of the time in group activities and discussion; listens when others talk but infrequently participates in whiteboard discussions</td>
<td>Rarely participates in group activities and discussion; does not listen when others are talking; is absent without prior notification</td>
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Assignment #4: Submit a final paper (at least 4 pages, double-spaced, 12 point font) demonstrating further evolution in your capacity to implement and enact chemistry modeling instruction methods in your classroom. (60 points: 20% of course grade)

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<tr>
<th>Assessment Item</th>
<th>54-60 points</th>
<th>48-52 points</th>
<th>42-46 points</th>
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<tr>
<td><strong>Organization</strong></td>
<td>Thesis statement, introduction, body, and close clearly discernable; essay moves regularly from generalities to specifics.</td>
<td>Has all the essential components but is somewhat disorganized; moves generally from generalities to specifics</td>
<td>Has some of the essential components but is disorganized; no real movement from generalities to specifics; somewhat disorganized</td>
<td>Thesis statement, introduction, body and close essentially indistinguishable; mostly specific information with few generalities; disorganized</td>
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<td><strong>Clarity</strong></td>
<td>Well written; no grammatical errors; easy and interesting reading; clear evidence of regular revision and proofing; key ideas are fully elaborated and illustrate what is meant; examples are provided as appropriate.</td>
<td>Reasonably well written; a few minor grammatical errors; easy and interesting reading; evidence of regular revision and proofreading; key points are made but not always elaborated.</td>
<td>Tolerably well written; a fair number of minor grammatical errors; a few major errors; confusing to reader; no evidence of regular review and revision; key points are made but not often elaborated.</td>
<td>Poorly written; a number of major and minor grammatical errors; essentially unreadable; paragraphs are a jumble of sentences and sentences are a jumble of words; gibberish; key points missing and/or not elaborated</td>
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<td><strong>Relevance</strong></td>
<td>All statements are relevant to the topic or bear on the question at hand; assists in clarifying topic or resolving issue</td>
<td>Most arguments are cogent, concise, and relevant; a small number of arguments provided and all are well reasoned; reader uncertain</td>
<td>Arguments are not always cogent, concise, and relevant; many arguments are given, but they are poorly reasoned; reader unconvinced</td>
<td>Arguments are not cogent, concise, and relevant; few arguments are given and they are poorly reasoned and insufficient to the task.</td>
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<td><strong>Depth</strong></td>
<td>Fully addresses main factors that make the topic important; deals with complexities; identifies difficulties; shows evidence of review of several major critical resources</td>
<td>Addresses most of the main factors that make this topic important; shows evidence of review of several resources</td>
<td>Addresses some of the main factors that make this topic important; shows some evidence of review of two or more resources</td>
<td>Addresses few, if any, of the main factors that make this topic important; clearly lacks evidence of appropriate review of resources</td>
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<td><strong>Breadth</strong></td>
<td>Addresses full range of subject matter very thoroughly; includes multiple important</td>
<td>Addresses full range of subject matter adequately; includes other important perspectives if pertinent to topic</td>
<td>Addresses full range of subject matter irregularly; provides no or incorrect alternative perspectives</td>
<td>Addresses full range of subject matter poorly; provides biased alternative perspectives</td>
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<td>Perspectives if pertinent to topic</td>
<td>Fairly good use of logic; provides good data, but perhaps draws improper conclusions on the basis of that data; orderly presentation of information and arguments</td>
<td>Logic weak, perhaps flawed, but attempts to draw appropriate conclusions from the limited amount of data provided; somewhat disorganized presentation of information</td>
<td>Logic flawed; draws inappropriate conclusions from data or draws conclusions without supporting data; garbled presentation; lacks logical flow of presentation</td>
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<td><strong>Logic</strong></td>
<td>Arguments provided are all well reasoned, “win the day” and make sense; first paragraph aligns with last; conclusions flow from evidence; order of presentation suggests use of a topical outline</td>
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<td><strong>Spelling and Punctuation</strong></td>
<td>Insignificant number of punctuation errors; no spelling errors</td>
<td>No spelling errors, and only a few punctuation errors</td>
<td>A modest number of spelling and punctuation errors</td>
<td>Numerous spelling and/or punctuation errors</td>
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<tr>
<td><strong>Format and Appearance</strong></td>
<td>Uses appropriate font, font size, line spacing, and border areas; good layout; good print quality</td>
<td>Fails to meet one of the guidelines for appropriate font, font size, line spacing, and border areas; good print quality</td>
<td>Fails to meet two or three guidelines of appropriate font, font size, line spacing, and border areas; fair print quality</td>
<td>Gross violation of format guidelines dealing with font, font size, line spacing, and border areas; poor print quality</td>
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**Assignment #5: Assessment of Basic Chemistry Concepts (30 points: 10% of course grade)**

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<th>27-30 points</th>
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<th>21-23 points</th>
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<td>A post-test raw score of 21 or higher, or a gain score of .5 or greater</td>
<td>A post-test raw score of 17–20, or a gain score of 0.40–0.49</td>
<td>A post-test raw score of 13–16, or a gain score of 0.30–0.39</td>
<td>A post-test raw score of 12 or less, or a gain of less than 0.29</td>
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<td>Gain = (post – pre)/(27 – pre)</td>
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