Science Curriculum Analysis Worksheet

Current research on science education emphasizes the importance of integrating the learning progressions from all three dimensions included in *A Framework for K-12 Science Education* in order to deepen student understanding of the big ideas connected to scientific phenomena. This Curriculum Analysis Worksheet is a tool that can be used to align your current instructional practices to a 3-dimensional model of instruction, designed to deepen student learning.

1.	Identify a science concept or concepts within the Arizona Science Standard from Strands 4, 5, or 6 that you teach at your grade level/course. Record the science concept, big idea/scientific phenomena, and the three-dimensional learning outcome(s).
2.	Identify learning progressions from each of the three dimensions that will be bundled together to build student conceptual understanding of the big idea/scientific phenomena selected in Step 1.
3.	a. Identify objectives from the Arizona Science Standard from Strands 1, 2 and 3 that align with the **Science and Engineering Practices** learning progression(s) you have identified in Step 2. b. Examine your current science curriculum to identify ways you can modify instruction to reach the vision of *A Framework for K-12 Science Education* while you currently teach grade level objectives aligned to the Arizona Science Standard.
4.	a. Identify the current objectives from the Arizona Science Standard from Strands 4, 5, and 6 that align with the **Disciplinary Core Ideas** learning progression(s) you have identified in Step 2. b. Examine your current science curriculum to identify ways you can modify instruction to reach the vision of *A Framework for K-12 Science Education* while you currently teach grade level objectives aligned to the Arizona Science Standard.
5.	a. Identify the current unifying concept(s) from page viii of the Arizona Science Standard that aligns with the **Crosscutting Concepts** learning progression(s) you have identified in Step 2. b. Examine your current science curriculum to identify ways you can modify instruction to reach the vision of *A Framework for K-12 Science Education* while you currently teach grade level objectives aligned to the Arizona Science Standard.
6.	a. Identify connections to grade level ELA/Literacy standards, as appropriate. b. Identify connections to grade level Mathematics standards and practices, as appropriate.

1.

Arizona Science Concept: Strand 5 Concept 4: Chemical Reactions

Big Idea/Scientific Phenomenon: The rate of a chemical reaction can be altered when the reacting particles experience a change in temperature, pressure, concentration or the addition of a catalyst.

Three Dimensional Learning Outcomes:

- 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

Science and Engineering Practices Learning Progression *(See Learning Progressions for 6-12 Science)*	Disciplinary Core Ideas Learning Progression *(See Learning Progressions for 6-12 Science)*	Crosscutting Concepts Learning Progression *(See Learning Progressions for 6-12 Science)*
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. **Constructing Explanations and Designing Solutions** • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**AZ Strand 5 Concept 4: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in total binding energy (i.e., the sum of all bond energies in the set of molecules) that are matched by changes in kinetic energy.	**Patterns** Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale; thus requiring improved investigations and experiments. **Systems and System Models** Students investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They use models and simulations to predict the behavior of a system, and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They design systems to do specific tasks.

3. Science and Engineering Practices

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<td>Current Practice</td>
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Identify performance objectives from Strands 1-3 within the Arizona Science Standard that align to the learning progressions listed above.
(Strand 1: Inquiry; Strand 2: History and Nature of Science; Strand 3: Science and Social Perspectives)

Concept 1: Observations, Questions, and Hypotheses
Formulate predictions, questions, or hypotheses based on observations. Evaluate appropriate resources.
PO 1. Evaluate scientific information for relevance to a given problem.
PO 2. Develop questions from observations that transition into testable hypotheses.
PO 3. Formulate a testable hypothesis.
PO 4. Predict the outcome of an investigation based on prior evidence, probability, and/or modeling (not guessing or inferring).

Concept 2: Scientific Testing (Investigating and Modeling)
Design and conduct controlled investigations.
PO 1. Demonstrate safe and ethical procedures (e.g., use and care of technology, materials, organisms) and behavior in all science inquiry.
PO 2. Identify the resources needed to conduct an investigation.
PO 3. Design an appropriate protocol (written plan of action) for testing a hypothesis:
• Identify dependent and independent variables in a controlled investigation.
• Determine an appropriate method for data collection (e.g., using balances, thermometers, microscopes, spectrophotometer, using qualitative changes).
• Determine an appropriate method for recording data (e.g., notes, sketches, photographs, videos, journals (logs), charts, computers/calculators).
PO 4. Conduct a scientific investigation that is based on a research design.
PO 5. Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs, and computers.

Concept 3: Analysis, Conclusions, and Refinements
Evaluate experimental design, analyze data to explain results and propose further investigations. Design models.
PO 1. Interpret data that show a variety of possible relationships between variables, including: positive relationship, negative relationship or no relationship
PO 2. Evaluate whether investigational data support or do not support the proposed hypothesis.
PO 4. Evaluate the design of an investigation to identify possible sources of procedural error, including: sample size, trials, controls, analyses

Concept 4: Communication
Communicate results of investigations.
PO 1. For a specific investigation, choose an appropriate method for communicating the results.
PO 2. Produce graphs that communicate data.
PO 3. Communicate results clearly and logically.
PO 4. Support conclusions with logical scientific arguments.
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<td>Vision of A Framework for K-12 Science Education</td>
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Gap Analysis/Curriculum Examination
Refer to the Science and Engineering practice learning progressions within the Learning Progressions for 9-12 Science document and your current curriculum to answer the following questions.
• What scientific phenomenon will students investigate and connect to the big idea?
• What practices are currently missing from my curriculum?
• What changes and refinements need to be made?
• What strategies/investigations can be implemented to achieve the vision?

Engage:
Set up a demonstration with two glow sticks, one in an ice bath and one in a hot water bath. When students arrive discuss the differences they see between the glow sticks. Ask students:
What will happen if the glow sticks are switched? What does this indicate about the chemical reaction in the glow stick?

Explore:
Students will design an experiment to test how different factors (temperature, surface area, concentration) affect the rate of a reaction. Provide them with water, Alka Seltzer® tablets (or other effervescent antacid tablets), hot plates or Bunsen burners, ice, glassware, etc. Ask students to develop the procedure and an appropriate data table to record the results of the experiment.

Explain:
Use the data collected from the student created experiment and teacher demonstrations to provide an evidence-based explanation (Claim – Evidence - Reasoning) of how different factors affect the rate of a reaction.

Extend:
How can a chemical reaction between copper (II) sulfate and aluminum occur? Students will conduct an experiment for the reaction between aqueous copper (II) sulfate and aluminum foil. (Salt is required as a catalyst for this reaction to occur.) The new data collected should be used improve upon the original evidence based explanation (Claim – Evidence- Reasoning) for reaction rate.
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4. Disciplinary Core Idea			
Current Performance Objectives	**Strand 5 Concept 4: Chemical Reactions** Investigate relationships between reactants and products in chemical reactions. PO 2. Identify the indicators of chemical change, including formation of a precipitate, evolution of a gas, color change, absorption or release of heat energy. PO 8. Quantify the relationships between reactants and products in chemical reactions (e.g., stoichiometry, equilibrium, energy transfers). PO 10. Explain the energy transfers within chemical reactions using the law of conservation of energy. PO 11. Predict the effect of various factors (e.g., temperature, concentration, pressure, catalyst) on the equilibrium state and on the rates of chemical reaction. **Concept 2: Science and Technology in Society** Develop viable solutions to a need or problem. PO 2. Recognize the importance of basing arguments on a thorough understanding of the core concepts and principles of science and technology.	***Vision of A Framework for K-12 Science Education***	**Gap Analysis** **Refer to the Content learning progressions within the Learning Progressions for 9-12 Science document and your current curriculum to answer the following questions.** • What core idea(s) is/are currently targeted within my current curriculum? • What changes and refinements need to be made? (add, refine, delete concepts) • What strategies/investigations can be implemented to achieve the vision? 1. Create a table for the class to document the evidence that a chemical reaction has occurred for each reaction that is done throughout the unit. 2. Have students create a model of the molecular movement of the molecules in the light stick demonstration. 3. Students show and explain their models of the light stick demonstration to the class. 4. Set up two demonstrations or show videos to show the decomposition of 30% hydrogen peroxide; elephant toothpaste and genie in the bottle. Both demos require a catalyst for the reaction to occur. Ask students: How do we know a chemical reaction occurred? What happens if we do not use the MgO in the reaction for genie the bottle? 5. Provide students with chemical reactions and the corresponding activation energy graphs to provide an example of how reaction rates and the energy requirements can change based on the addition of a catalyst. 6. Graph data collected in student experiments for rate of reaction. Have students compare the graphs and identify any trends that are seen in the data. 7. Have students identify a real world example where increasing the rate of a reactions has a positive effect and one where it has a negative effect.

5. Crosscutting Concepts			
Current Crosscutting Concepts	**Unifying Concepts and Processes (Crosscutting concepts)** **Listed in page viii of the front matter of the Arizona Science Standard, and explained in the National Science Education Standards (1995) pp. 115-119** Systems, Order, and Organization Evidence, Models, and Explanation	**Vision of *A Framework for K-12 Science Education***	**Gap Analysis** **Refer to the Crosscutting Concepts learning progressions within the Learning Progressions for 9-12 Science document and your current curriculum to answer the following questions.** • How is/are the crosscutting concept(s) made explicit within my current curriculum? • What changes and refinements need to be made? • What strategies/investigations can be implemented to achieve the vision? **Patterns** Provide opportunities for students to see the patterns in the evidence of chemical reactions including production of gas, color change, formation of a precipitate, and absorption or release of energy. **Systems and System Models** Provide opportunities for students to evaluate activation energy graphs and discuss the patterns that exist in the type of energy input and output in the systems. Provide opportunities for students to model the kinetic molecular process that occurs and changes due to the rate of reaction.

6. Connections

Other Content Area Standards	Identify other Content Area Standards that will build student understanding of this concept or phenomenon, especially those in ELA/Literacy and Mathematics/Practices.	Connections to Instruction	Gap Analysis Refer to the Other content standards that are being used as a connection to answer the following questions.
	RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. **SL.11-12.2.** Integrate multiple sources of information presented in diverse media and formats (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. **SL.11-12.4.** Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. **MP.2.** Reason abstractly and quantitatively. **HS N-Q.A.2** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HS N-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.		• How are the connected standards explicitly taught within my current curriculum? • What changes and refinements need to be made? • What strategies/investigations can be implemented to achieve the vision? Reading • Provide data and graphs or informational text for students to read and interpret regarding activation energy. Writing • Students write procedures for experiment devised to test rate of reactions for an Alka Seltzer® tablet. • Students display data collected in appropriate ways, and explain how the information provides evidence to support a claim. • Students write explanations to explain the factors that affect rate of a reaction. Speaking and Listening • Students participate in small group discussions to devise the plan for their experiment. • Students present model of the kinetic movement in the light stick demo to the class. Mathematics • Evaluate graphical data for rates of reaction to provide evidence to support claims about rate of reactions.