The 5 E Learning Cycle Model

| Engagement             | Object, event or question used to engage students. |
|                       | Connections facilitated between what students know and can do. |
| Exploration           | Objects and phenomena are explored. |
|                       | Hands-on activities, with guidance. |
| Explanation           | Students explain their understanding of concepts and processes. |
|                       | New concepts and skills are introduced as conceptual clarity and cohesion are sought. |
| Elaboration           | Activities allow students to apply concepts in contexts, and build on or extend understanding and skill. |
| Evaluation            | Students assess their knowledge, skills and abilities. Activities permit evaluation of student development and lesson effectiveness. |

Adapted from Bybee, R.W. et al. (1989).

Planning inquiry lessons using the Learning Cycle model

First used as an inquiry lesson planning model in the Science Curriculum Improvement Study (SCIS) program, a K-6 science program in the early 1970s, the early learning cycle model had 3 stages (exploration, invention, discovery). Using the learning cycle approach, the teacher "invents" the science concept of the lesson in the 2nd stage (rather than defining it at the outset of the lesson as in the traditional approach). The introduced concept subsequently enables students to incorporate their exploration in the 3rd stage and apply it to new examples. Many examples of learning cycles have been described in the literature (Barman, 1989; Ramsey, 1993; also see Osborne and Wittrock, 1983). The 5E Learning Cycle (Bybee) is used in the new BSCS science programs as well as in other texts and materials.
Using a Learning Cycle Model in Lesson Planning

The chart below is based upon a four step learning cycle model as featured in Bentley, Ebert & Ebert (2000), but the examples of learner and teacher behaviors provided here can be adapted to fit other learning cycle models.

Engage: Learner has a need to know, therefore, defines questions, issues or problems that relate to his/her world.

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>calls up prior knowledge</td>
<td>poses problems</td>
</tr>
<tr>
<td>has an interest</td>
<td>asks questions</td>
</tr>
<tr>
<td>experiences doubt or disequilibrium</td>
<td>reveals discrepancies</td>
</tr>
<tr>
<td>has a question(s)</td>
<td>causes disequilibrium or doubt</td>
</tr>
<tr>
<td>identifies problems to solve, decisions to be made, conflicts to be resolved</td>
<td>assess prior knowledge</td>
</tr>
<tr>
<td>writes questions, problems, etc.</td>
<td></td>
</tr>
<tr>
<td>develops a need to know</td>
<td></td>
</tr>
<tr>
<td>self reflects and evaluates</td>
<td></td>
</tr>
</tbody>
</table>

Investigate (Explore): Learner gathers, organizes, interprets, analyzes, evaluates data

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypothesizes and predicts</td>
<td>questions and probes</td>
</tr>
<tr>
<td>explores resources and materials</td>
<td>models when needed</td>
</tr>
<tr>
<td>designs and plans</td>
<td>makes open suggestions</td>
</tr>
<tr>
<td>collects data</td>
<td>provides resources</td>
</tr>
<tr>
<td>builds models</td>
<td>provides feedback</td>
</tr>
<tr>
<td>seeks possibilities</td>
<td>assesses understandings and processes</td>
</tr>
</tbody>
</table>
**Explain and Clarify:** Learner clarifies understandings discovered, reaches conclusions or generalizations and communicates in varying modes and forms.

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>clarifies understandings</td>
<td>provides feedback</td>
</tr>
<tr>
<td>shares understandings for feedback</td>
<td>asks questions, poses new problems and issues</td>
</tr>
<tr>
<td>forms generalizations</td>
<td>models or suggests possible modes</td>
</tr>
<tr>
<td>reflects on plausibility</td>
<td>offers alternative explanations</td>
</tr>
<tr>
<td>seeks new explanations</td>
<td>enhances or clarifies explanations</td>
</tr>
<tr>
<td>employs various modes for explanation (writing, art, etc)</td>
<td>evaluates explanations</td>
</tr>
</tbody>
</table>

**Expand:** Learner applies these conclusions or generalizations to solve problems, make decisions, perform tasks, resolve conflicts or make meaning.

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>applies new knowledge</td>
<td>asks questions</td>
</tr>
<tr>
<td>solves problems</td>
<td>provides feedback</td>
</tr>
<tr>
<td>makes decisions</td>
<td>provides resources</td>
</tr>
<tr>
<td>performs new related tasks</td>
<td>makes open suggestions</td>
</tr>
<tr>
<td>resolves conflicts</td>
<td>models when necessary</td>
</tr>
<tr>
<td>plans and carries out new project</td>
<td>evaluates</td>
</tr>
<tr>
<td>asks new questions</td>
<td></td>
</tr>
<tr>
<td>seeks further clarification</td>
<td></td>
</tr>
</tbody>
</table>

Inquiry Indicators: What Are the Students Doing?

An On-the-Run Reference Guide to What Inquiry "Looks Like"

Imagine yourself in an inquiry classroom. What would you expect to see? These guidelines from the Vermont Elementary School/Continuous Assessment Project were created by observing students as they did "hands-on, minds-on" exploration in the classroom. "The intent is not to use the guide as a checklist," they said, "but to use it as a statement of what we value in the areas of science process, science dispositions, and science content development."

When students are doing inquiry-based science, an observer will see that:

Students View Themselves as Active Participants in the Process of Learning

1. They look forward to doing science.
2. They demonstrate a desire to learn more.
3. They seek to collaborate and work cooperatively with their peers.
4. They are confident in doing science; they demonstrate a willingness to modify ideas, take risks, and display healthy skepticism.
5. They respect individuals and differing points of view.

Students Accept an "Invitation to Learn" and Readily Engage in the Exploration Process

1. They exhibit curiosity and ponder observations.
2. They take the opportunity and time to try out and persevere with their own ideas.

Students Plan and Carry Out Investigations

1. They design a fair test as a way to try out their ideas, not expecting to be told what to do.
2. They plan ways to verify, extend, or discard ideas.
3. They carry out investigations by handling materials with care, observing, measuring, and
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3. They carry out investigations by handling materials with care, observing, measuring, and recording data.

Students Communicate Using a Variety of Methods

1. They express ideas in a variety of ways: journals, reporting drawing, graphing, charting, etc.
2. They listen, speak, and write about science with parents, teachers, and peers.
3. They use the language of the processes of science
4. They communicate their level of understanding of concepts that they have developed to date.

Students Propose Explanations and Solutions and Build a Store of Concepts

1. They offer explanations both from a "store" of previous experience and from knowledge gained as a result of ongoing investigation.
2. They use investigations to satisfy their own questions.
3. They sort out information and decide what is important (what does and doesn't work).
4. They are willing to revise explanations and consider new ideas as they gain knowledge (build understanding).

Students Raise Questions

1. They ask questions--verbally or through actions.
2. They use questions that lead them to investigations that generate or redefine further questions and ideas.
3.
   They value and enjoy asking questions as an important part of science.

Students Use Observations

1. They observe carefully, as opposed to just looking.
2. They see details, seek patterns, detect sequences and events; they notice changes, similarities, and
3. They make connections to previously held ideas.

Students Critique Their Science Practices

1. They create and use quality indicators to assess their own work.
2. They report and celebrate their strengths and identify what they'd like to improve upon.
3. They reflect with adults and their peers.

Inquiry Indicators: What is the Teacher Doing?

In the inquiry classroom, the teacher's role becomes less involved with direct teaching and more involved with modeling, guiding, facilitating, and continually assessing student work. Teachers in inquiry classrooms must constantly adjust levels of instruction to the information gathered by that assessment.

The teacher's role is more complex, including greater responsibility for creating and maintaining conditions in which children can build understanding. In this capacity, the teacher is responsible for developing student ideas and maintaining the learning environment.

Besides the process skills that the student must hone in the inquiry classroom, there are also skills a teacher must develop in order to support student learning of scientific ideas. When you enter an inquiry classroom, you may see that the:

Teachers Model Behaviors and Skills

1. They show children how to use new tools or materials.
2. They guide students in taking more and more responsibility in investigations.
3. They help students design and carry out skills of recording, documenting, and drawing conclusions.

Teachers Support Content Learning

1. They help students form tentative explanations while moving toward content understanding.
2. They introduce tools and materials and scientific ideas appropriate to content learning.
3. They use appropriate content terminology, as well as scientific and mathematical language.

Teachers Use Multiple Means of Assessment

1. They are sensitive to what children are thinking and learning, and identify areas in which children are struggling.
2. They talk to children, ask questions, make suggestions, share, and interact.
3. They move around and make themselves available to all students.
4. They help children go to the next stage of learning with appropriate clues and prompts.

Teachers Act as Facilitators

1. They use open-ended questions that encourage investigation, observation, and thinking.
2. They carefully listen to students' ideas, comments, and questions, in order to help them develop their skills and thought processes.
3. They suggest new things to look at and try, and encourage further experimentation and thinking.
4. They orchestrate and encourage student dialogue.


**Problem-solving strategies**

According to Hyerle (1996), "The central problem that constructivist educators face is not a [lack of] guiding theory, but concrete strategies and tools for institutionalizing these theoretical and practical understandings into more inclusive classrooms." (p. 15).

**Compass Quest** is a consortium of 12 schools working to infuse into their curriculums decision-making and problem-solving skills. The Association for Supervision and Curriculum Development (ASCD) provides logistical support for the consortium. The Compass Quest
schools teach four question-based problem-solving strategies, one for each of four different situations. The strategy names were derived from the problem-solving steps involved: SCAN, FIND, SELECT, and PLAN. Many corporations (e.g. Honda, Uniroyal, and Hewlett-Packard) and government agencies, such as NASA, have used these strategies for over 40 years.

Compass Quest offers an effective way to begin using these processes:

- **Situation Appraisal** - how to evaluate "the whole picture" by breaking issues down into chunks, establishing priorities and determining appropriate steps to resolve the issues.
- **Decision Analysis** - a process for making a decision when the choice between alternatives is unclear. Involves systematically examining the elements of and decision-objectives, choices and risks.
- **Problem Analysis** - how to find the root cause of problems so that corrective actions can be taken.
- **Potential Problem Analysis** - tools for thinking about potential problems and planning preventive and contingent actions.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Definition</th>
<th>Requirements</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complex situation</strong></td>
<td>Multifaceted scenarios have multiple variables and opinions.</td>
<td>Understanding of relevant variables, their priorities, and possible action plans</td>
<td>See the issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Clarify the issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Assess priorities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Name next steps</td>
</tr>
<tr>
<td><strong>Problem situation</strong></td>
<td>Something has gone wrong or an unknown cause has produced some undesired effect.</td>
<td>Analysis of relevant data to evaluate possible causes and determine true cause</td>
<td>Focus on the problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Identify what is and is not</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Narrow possible causes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Determine true cause</td>
</tr>
<tr>
<td><strong>Decision situation</strong></td>
<td>One course of action or solution must be selected from among several possible options.</td>
<td>Selection of the best possible option after evaluating options against criteria and then considering risks.</td>
<td>State the decision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Establish and classify objectives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>List alternatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Evaluate alternatives</td>
</tr>
</tbody>
</table>

http://faculty.mwsu.edu/west/maryann.coe/coe/inquire/inquiry.htm
<table>
<thead>
<tr>
<th>Implementation situation</th>
<th>Consider risks</th>
<th>Trust your work</th>
<th>Predict potential problems</th>
<th>List likely causes</th>
<th>Agree on preventive actions</th>
<th>Note contingent actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upcoming plans, changes, and actions will be implemented.</td>
<td>Identification of actions needed for successful implementation and identifying potential problems and how to handle them.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Richetti & Sheerin, 1999, p. 60.)


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**Priming the Pump**: Peter Elbow's prompts to help students explore topics, objects, places, issues

**Questions to help a student write about someone s/he has studied or read about:**

- Describe _ as an ordinary person.
- What was/is special or unique about _ ?
- Imagine _ were the opposite sex: describe the life s/he would have lived.
- What if _ had lived in a different era, such as _ : describe the life s/he would have lived.
- Make up or guess what might have been an important event in _'s childhood.
- Create a soap opera plot with _ in it.
- What does _ most need to cry about?
- What should _ be most appreciated for?
- What would _'s mother or father say about _ ?
- What would _ be likely to dream about?
Questions to help a student write about someone's life as a whole:

- What about _'s life remained unchanged?
- Describe _'s life and character as determined by important changes or turning points.
- Imagine you believe people are truly free and that they somehow choose or cause what happens to them. Describe _'s life.
- Imagine you believe people are not free, but are determined by events they can't control. Describe _'s life.
- Describe _'s life as a product of national, cultural, and/or ethnic influences.
- Describe _'s life as primarily a product of personal and family influences.
- Describe _'s life as primarily a product of economic and class influences.
- Describe _'s character as a solution to past problems.
- Describe _'s life as mainly the product of conditioning - behavior rewarded and behavior punished.

Questions to help a student write about a place.

Teacher: "Imagine a place and go there in your imagination. Pick a particular time of the year and of the day. Imagine it - feel the weather, hear the sounds. Connect with it for a moment."

- How does "being there" influence your mood?
- Imagine the history of the place from the beginning of the world. Write about this history.
- If someone said, "It's a _ day," what kind of day would it be?
- Imagine you have always been blind. Describe your place.
- What story, song, or movie does your place remind you of?
- What is the first thing that comes to mind which your place would never remind you of?
- What other place does your place make you think of?
- In what weather is your place most itself?
· What rhythms do you discern in your place - things that happen there at regular intervals?
· How do you think your place will end?

**Questions to help a student write about an object:**

· Teacher: "Think of a particular moment in which this object was meaningful or important to you. Close your eyes and take yourself back into that moment. Imagine the object in that scene - the time of day, the time of year, the smells, your feelings."
· If you had never seen this object before, what would you notice when you first looked at it?
· Tell a way you might take it apart to get down to its basic ingredients.
· Tell how this particular object came to exist - how it came to be put together.
· Tell its history for the last five minutes.
· What ways is it used?
· What ways might it be used but isn't?
· What are three ways it could not possibly be used?
· What three things does the object remind you of (or represent)?

**Questions to help a student write about an artifact:**

· Pretend you made it and are very dissatisfied. Why are you dissatisfied with it?
· Imagine you made it as a gift for someone you know - a real person in your life. Who? How did s/he feel about your gift?
· Imagine that everyone owned this object. What would be the effects?
· What is someone most likely to notice the first time s/he sees it?
· What would you notice about this if you had never seen anything like it before?
· What detail or part of it says more about it than any other?

· Is this male or female?

· Imagine it as a part of an evolutionary process. What did it evolve from? What will it evolve into?

· If this ends up as the only human artifact transported to Mars and found in the next millennium by an alien scouting party, what guesses or conclusions would they reach about us?

"Angles" - Suggestions to help a student write about a problem or dilemma:

· The pump needs priming.

· Defective materials.

· Too many cooks.

· A committee designed it or executed it.

· The problem is that God is angry.

· It's a problem of addiction.

· The problem has been stated wrong.

· The problem comes from bad data.

· It's a Gordian knot - quit trying to untie it and cut through it with a sword.

· The problem is a car that won't start in the winter.

· It's a problem of logic.

· It looks like a problem but really everything is okay if you take the right point of view.

· Assume a problem has no solution. What is the sensible course of action or strategy that follows from this conclusion.

· It's sabotage.

· It's a problem of numbers.

· Its just something wrong with digestion - eating the wrong thing, getting diarrhea, constipation, vomiting.

· It's a problem of people - incompatible temperaments, struggling for
dominance, loving each other but unable to admit it, feeling scared but not admitting it.

- Outdated design.
- It's a problem of money (too little/too much).
- It's a matter of being sick - needs a drug, a long recuperation, helping the patient cope with the impossibility of cure.
- It's mental illness - needs shock therapy, talking therapy, group therapy, conditioning therapy, help and support, recognition that society is crazy and the patient sane.


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**Fostering Inquiry:**

<table>
<thead>
<tr>
<th>Questions for Quality Thinking</th>
<th>Strategies to Extend Student Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge</strong> - Identification and recall of information</td>
<td>Remember &quot;wait time I and II&quot;</td>
</tr>
<tr>
<td>Who, what, when, where, how____?</td>
<td>Provide at least three seconds of thinking time after a question and after a response.</td>
</tr>
<tr>
<td>Describe______________________</td>
<td>Utilize &quot;thinking-pair-share&quot;</td>
</tr>
<tr>
<td><strong>Comprehension</strong> - Organization and selection of facts and ideas</td>
<td>Allow individual thinking time, discussion with a partner, and then open up the class discussion.</td>
</tr>
<tr>
<td>Retell____in your own words.</td>
<td><strong>Ask &quot;follow-ups&quot;</strong></td>
</tr>
<tr>
<td>What is the main idea of ______?</td>
<td>Why? Do you agree? Can you elaborate?</td>
</tr>
<tr>
<td><strong>Application</strong> - Use of facts, rules, principles</td>
<td>Tell me more. Can you give an example?</td>
</tr>
<tr>
<td>How is ____an example of <strong><strong>? How is____related to</strong></strong>?</td>
<td><strong>Withold judgment</strong></td>
</tr>
<tr>
<td>Why is____significant?</td>
<td>Respond to student answers in a non-evaluative fashion</td>
</tr>
<tr>
<td><strong>Analysis</strong> - Separation of a whole into component parts</td>
<td><strong>Ask for summary</strong> (to promote active listening)</td>
</tr>
<tr>
<td>What are the parts or features of____?</td>
<td></td>
</tr>
</tbody>
</table>

http://faculty.mwsu.edu/west/maryann.coe/coe/inquire/inquiry.htm
| **Classify**___according to ___. |
| Outline/diagram/web________ |
| How does__compare/contrast with___? |
| What evidence can you list for___? |
| **Synthesis**-Combination of ideas to form a new whole |
| What would you predict/infer from____? |
| What ideas can you add to___? |
| How would you create/design a new___? |
| What might happen if you combined___with ___? |
| What solutions would you suggest for___? |
| **Evaluation**-Development of opinions, judgements, or decisions |
| Do you agree___? What do you think about___? |
| What is the most important___? |
| Prioritize____? |
| How would you decide about___? What criteria would you use to assess___? |

"Could you please summarize John's point?"

**Survey the class**-"How many people agree with the author's point of view?"("thumbs up, thumbs down")

**Allow for student calling**-"Richard, will you please call on someone else to respond?"

**Play devil's advocate**-require student to defend their reasoning against different points of view.

**Ask students to "unpack their thinking"**--"Describe how you arrived at your answer."("think aloud")

**Call on students randomly**-Not just those with raised hands.

**Student questioning**- Let the students develop their own questions

**Cue student responses**-"There is not a single correct answer for this question. I want you to consider alternatives."

Source: Frank Lyman, Maryland Department of Education workshop handout, Baltimore, MD, 1980.

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**Resources on Inquiry Teaching**

**Books**


Improving Instruction.


**Web Sites**

- American Association for the Advancement of Science/Benchmarks for Science Literacy
- Exploratorium Institute for Inquiry
- National Science Education Standards
- National Science Foundation

Created by: Mary Ann Coe, D. Ed.
West College of Education
Updated: November 2001