Teaching Critical Thinking

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Key Components

• Utilize a defined process or model
• Incorporate and practice the model at all levels (faculty, TAs, and students)
• Require reflection and metacognition in all aspects of a course or experience
  – Reflection: conscious exploration of one’s experience
  – Metacognition: thinking about one’s own thought processes
Program Level Learning Outcome Rubric – Zachry Department of Civil Engineering, Dwight Look College of Engineering, Texas A&M University

8. Problem recognition and solving

After graduation, the student will be able to:

Develop problem statements and solve fundamental civil engineering problems by applying appropriate techniques and tools.

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
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<tbody>
<tr>
<td><strong>Desired level at graduation.</strong></td>
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<td>Level when student enters CVEN (after completing CBK).</td>
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<tr>
<td><strong>Problem Recognition</strong></td>
<td>Synthesize from disparate information a comprehensive statement of a problem suitable for formulating a civil engineering solution.</td>
<td>Define the types of problems that an individual civil engineer (her/himself or another person) is competent to address consistent with ethical standards for licensed engineers. Define the information required to characterize an engineering problem and formulate a solution.</td>
<td>Categorize a wide range of civil engineering problems among subdisciplines and branches of knowledge (e.g., structural problems versus geotechnical problems versus construction management problems, etc.).</td>
<td>Identify problems that civil engineers typically solve in practice (e.g., long traffic delays, inadequate water supplies, etc.).</td>
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<td><strong>Problem Generalization</strong></td>
<td>Design solution methods based on approaches in different application areas.</td>
<td>Explain generalized concepts and manifestation in different areas.</td>
<td>Identify commonalities between civil engineering and problems in everyday life.</td>
<td>Identify types of problems found in everyday life.</td>
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<td><strong>Problem Solving</strong></td>
<td>Apply, working independently and in teams, standard civil engineering problem solving techniques with high levels of uncertainty and ill-definition.</td>
<td>Apply, working independently and in teams, standard civil engineering problem solving techniques with minor levels of uncertainty and ill-definition.</td>
<td>Explain the use of multiple civil engineering problem solving techniques for well-defined problems in multiple subdisciplines.</td>
<td>Use basic mathematical and scientific principles to solve elementary, well defined problems in math and science.</td>
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<td><strong>Critical Thinking</strong></td>
<td>Analyze and critique information, perspectives, experiences, and personal thought processes when analyzing problems and synthesizing problem solving approaches.</td>
<td>Demonstrate awareness or analysis of one’s own learning or thinking processes to recognize and solve problems.</td>
<td>Summarize strategies in analyzing one’s own learning or thinking processes in order to recognize and solve problems.</td>
<td>Recognize one’s own learning and thinking processes and fundamental limitations.</td>
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Models help support and develop critical thinking skills

- Paul and Elder: Critical Thinking Concepts and Tools
- Wolcott and Lynch: Steps for Better Thinking
- Chaffee: Thinking Critically
Critical Thinker
Paul and Elder (2001)

- Raises vital questions and problems, formulating them clearly and precisely;
- Gathers and assesses relevant information, using abstract ideas to interpret it effectively;
- Comes to well-reasoned conclusions & solutions, testing them against relevant criteria & standards;
- Thinks open-mindedly within alternative systems of thought, recognizing & assessing, assumptions, implications, and practical consequences; and
- Communicates effectively with others in figuring out solutions to complex problems.
Elements of Thought

Adapted from Paul & Elder, 2001

- **Points of View**
  - Frame of reference, perspective, orientation

- **Purpose of Thinking**
  - Goal or objective

- **Question at Issue**
  - Problem, issue

- **Information**
  - Data, facts, observations, experiences

- **Interpretation & Influence**
  - Conclusions, solutions

- **Assumptions**
  - Presuppositions, taking for granted

- **Concepts**
  - Theories, definitions, axioms, laws, principles, models

- **Implications & Consequences**
  - Elements of Thought
Checklist for Reasoning
Paul and Elder (2001)

• All reasoning
  – has a **PURPOSE**
  – is an attempt to **FIGURE** something out, to settle some **QUESTION**, solve some **PROBLEM**
  – is based on **ASSUMPTIONS**
  – is done from some **POINT OF VIEW**
  – is based on **DATA, INFORMATION & EVIDENCE**
  – is expressed through, and shaped by **CONCEPTS & IDEAS**
  – contains **INFERENCES** or **INTERPRETATIONS** by which we draw **CONCLUSIONS** and give meaning to data
  – has **IMPLICATIONS** and **CONSEQUENCES**
# Developmental Framework for Critical Thinking

## Foundation Knowledge
- Identify The Problem
- Explore Interpretations & Connections
- Prioritize Alternatives
- Envision Strategic Innovation

## Performance Patterns
- Confused Fact Finder
- Biased Jumper
- Perpetual Analyzer
- Pragmatic Performer
- Strategic Re-visioner

## Interventions
1. **Step 1**
   - Distinguish relevant & irrelevant Information
   - Read conflicting opinions

2. **Step 2**
   - Relate assumptions & biases
   - Analyze pros & cons

3. **Step 3**
   - Prioritize issues and information
   - Justify assumptions

4. **Step 4**
   - Articulate vision
   - Reinterpret information

Steps for Better Thinking Performance Patterns, [http://www.wolcrottlynch.com](http://www.wolcrottlynch.com)
Thinking Critically
Carefully exploring the thinking process to clarify our understanding and make more intelligent decisions.

Becoming a Critical Thinker
- Thinking actively
- Carefully exploring situations with questions
- Thinking independently
- Viewing situations from different perspectives
- Supporting diverse perspectives with reasons and evidence
- Discussing ideas in an organized way
- Analyzing issues

Chaffee (2014)
Developing Good Questions

Powerful Questions:

• Generate curiosity
• Stimulate reflective conversation
• Are thought-provoking
• Invite critical thinking and new possibilities
• Stay with students
• Touch a deep meaning
• Ask the un-askable
• Evoke more questions

“If I had an hour to solve a problem and my life depended on the solution, I would spend the first 55 minutes determining the proper question to ask, for once I know the proper question, I could solve the problem in less than five minutes.”

-Albert Einstein
Example From Group Project Reflection Exercise

- Are you satisfied with how our group is working together?
- *When* have you been most satisfied with how our group works together?
- *What* is it about working with our group that you find most satisfying?
- *Why* might it be that our group has had its ups and downs?
Question Activity

• Think of a concept you teach in your class and develop questions at each level in the pyramid that you can pose to students.

• How did the questions change the level of thinking required to answer it?

• Share with a colleague.


Incorporating Critical Thinking

- Gather baseline data
- Refine coursework over several semesters (a sequence of courses not just one)
  - Pay particular attention to weaknesses in the ability of your students to identify the problem, relevant information, and uncertainties
  - Introduce students to your chosen model
  - Recognize need for students to give up old ways of thinking and adopt new ways of thinking
- Consider implementation across the curriculum
References


• WolcottLynch Educator Resources: [http://www.wolcottlynch.com/EducatorResources.html](http://www.wolcottlynch.com/EducatorResources.html)
Bloom’s Revised Taxonomy

Creating—Generating new ideas, products, or ways of viewing things. Outcome verbs: design, construct, plan, produce, invent.

Evaluating—Justifying a decision or course of action. Outcome verbs: Hypothesize, critique, experiment, judge, conclude.

Analyzing—Breaking information into parts to explore understandings and relationships. Outcome verbs: Compare, organize, deconstruct, interrogate, diagram, correlate.

Applying—Using information in another familiar situation. Outcome verbs: Implement, carry out, use, execute, solve.

Understanding—Explaining ideas or concepts. Outcome verbs: Interpret, summarize, paraphrase, classify, explain.

Remembering—Recalling information. Outcome verbs: Recognize, list, describe, retrieve, name, find.
Bloom’s Taxonomy

Bloom’s Original

Anderson’s Revised
Skills Assessed by the Critical thinking Assessment Test (CAT)

Evaluating Information and Other Points of View

- Separate factual information from inferences
- Interpret numerical relationships in graphs
- Understand the limitations of correlational data
- Evaluate evidence and identify inappropriate conclusions
Creative Thinking

- Identify alternative interpretations of data for observations
- Identify new information that might support or contradict a hypothesis
- Explain how new information can change a problem
Learning and Problem Solving

• Separate relevant from irrelevant information
• Integrate information to solve problems
• Learn and apply new information
• Use mathematical skills to solve real-world problems

Communication

• Communicate ideas effectively