*"Education can and should do much to influence social, moral and intellectual discovery by stimulating critical attitudes of thought in the young";*
-George Bernard Shaw

If having solid writing and fundamental math skills are required to enter college, the skills of critical thinking and problem solving are what you must develop while in college. Higher levels of cognitive skill prepare students to become successful professionals and mature individuals.

What is critical thinking and why is it important? Critical thinking according to Paul and Elder (2008) is "that mode of thinking – about any subject, content, or problem – in which the thinker improves the quality of his or her thinking by skillfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them."; Critical thinking includes the ability to understand, conceptualize, analyze, and evaluate information in order to solve a problem.

When defining critical thinking, the National Council for Excellence in Critical Thinking (1987) lists the intellectual standards of clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness.

A critical thinker is someone who:

1. Asks vital questions and raises issues, formulating them clearly and precisely.
2. Collects and evaluates information that is relevant, interprets it effectively, arrives at conclusions, provides solutions that are well-reasoned, and tests them against established criteria and standards.
3. Is open-minded to alternative ideas and ways of thinking, questioning assumptions and implications.
4. Is able to communicate with and work with others, figuring out solutions to complex problems.

**Bloom's Taxonomy**

To succeed in college and in life means making sound decisions that go beyond simple knowledge. This is why the psychologist Benjamin Bloom and his colleagues developed a hierarchy of critical thinking skills that makes it possible for educators to assess their students. Educators use this taxonomy to design curriculum and enable students to learn and demonstrate the cognitive skills of critical thinking.

Making informed and wise decisions involves going through the six levels defined by Bloom. The first three levels of this hierarchy are the lower-order thinking skills generally required of the lower division courses, while the last three are the higher-order thinking skills expected more of the upper division courses.

Visualize the taxonomy as a pyramid.

1. *Knowledge* – Remembering previously learned material. When tests and assignments involve memorizing facts, identifying information, and recalling terminologies such as those found in objective tests, this is to test knowledge.
2. *Comprehension* – Grasping the meaning of material. When understanding and comprehending what was read in the material and heard in lectures is required, as when you have to paraphrase, state in your words, outline ideas, and interpret the meaning of information learned, this is to test comprehension.
3. *Application* – Using information in concrete situations. When you are required to apply concepts and theories discussed in the course to real-life situations or simulated scenarios, this is a test of deeper understanding. This type of assessment usually comes in the form of case studies, problem solving, and providing examples.
4. *Analysis* – Breaking down material into parts. When you are asked to break down component parts of a complex idea and then tie, relate, dissect, compare, and contrast the parts of an idea to one another, this is to test a higher order of thinking skill.
5. *Synthesis* – Putting parts together into a whole. This type of assessment usually involves more writing of reports, research papers, and essay papers. This assessment type also may involve projects that require integrating ideas, summarizing other studies, finding relevant materials from which to build new ideas, looking for interconnections, creating and coming up with new ideas based upon what has been learned.
6. *Evaluation* – Judging the value of information for a purpose. When professors use directive questions such as criticize, form opinions, discern, list advantages and disadvantages, and use criteria for evaluation, this requires making judgments of knowledge. This is assessing high order thinking skills, the foundation of good decision making.

Resource:

View this image for a visual understanding of Bloom's taxonomy: <http://www.unc.edu/learnnc/kinetic-connect/noframes.html>

**How to think critically**

One thing professors like to see in student assignments is work that demonstrates critical thinking. This means the paper is well-thought-out, well-reasoned, logical, and comprehensive. Ideas are related and connected. The approach is original and creative.

How does the student go about thinking critically? Is there a process? Here are some guidelines:

1. *Be inquisitive and ask yourself questions* – Find out as much as you can about the topic. The more content material you have to work with, the more substance your work will have. Organize the materials you have according to how they are related, or into categories. How do they fit together? Ask if the information you have is significant or relevant.
2. *Be interested and persistent* - Have a positive attitude about what you are doing. Be willing to push your limits and not be easily content with what you have. Explore some more and keep searching for answers and solutions. Keep gathering materials.
3. *Be creative* – Think outside the box in terms of where to find materials beyond those available from the usual resources. Did you think there might be recorded speeches, movies, or clips made about the topic? How about personal interviews? Is there a novel, fresh way of presenting your ideas?
4. *Write down your thoughts* – Sometimes your thoughts and ideas escape your memory, so be sure to write them down immediately. It has been said that writing down thoughts and ideas trigger more thoughts and ideas.
5. *Don't miss any detail* – Paying attention to detail shows a concern for accuracy, credibility, and care.
6. *Vary your perspectives* – Do not limit yourself to one point of view. Examine all possible ways of looking at the question and coming up with solutions. See all sides of the issue and keep an open mind.
7. *Be logical* - Demonstrate sound use of judgment and good reasoning. Your ideas have to make sense and must be supported by materials from credible sources.
8. *Communicate clearly* – Once you pull your ideas together and start writing, be clear in expressing your ideas. Use the correct words and appropriate writing style.

**Concept Mapping**

*Concept Mapping* is a tool for enhancing many of the types of thinking and learning required by students in college study. It is a diagram showing the relationships among concepts and a tool for organizing information.

Resource:

Watch this informative video on Concept Mapping and learn how you can use it as a strategy for critical thinking and problem solving.

Concept Knowledge Maps: [Windows Media](http://maclife.mcmaster.ca/academicskills/media/wmv/2006_CK_maps.wmv) | [mp3](http://maclife.mcmaster.ca/academicskills/media/mp3/2006_CK_maps.mp3) | [Quick Time](http://maclife.mcmaster.ca/academicskills/media/mov/2006_CK_maps.mov)

**Problem Solving**

In college, problem solving is a required skill. It is particularly important for physical science courses such as math, science, and computer science. If you don't learn to solve problems quickly and accurately, you may not do well with your exams. It is not just a matter of knowing the concepts. You also must understand the procedure to arrive at the correct answer.

The problem-solving process can be divided into four major stages:

1. *Defining the problem* – Before doing anything else, you must understand the problem clearly. Misunderstanding the problem will lead you down the wrong track, no matter how much effort you put in. What are you trying to find out? Can you clearly state in your own words what the problem is?
2. *Gathering and interpreting information* – It is important to gather as much information as you can find, but the information needs to be relevant. See the problem from different angles. State your criteria and compare the information you have against your criteria. Look at all the pros and cons. Are there other options? When deciding on a plan of action, first consider all options and then narrow down the list.
3. *Developing and implementing a plan of action* – Once you come up with a plan, ask yourself how this plan would work. For example, if you opted to go to an online college, what must you do? What preparations and requirements do you have to meet?
4. *Evaluating the plan* – Ask yourself what the likely consequences are. Justify why you picked one choice over another.

**Problem solving in Math and Science**

Many college students are challenged by problem solving in mathematics and science. Some students have higher aptitudes than others when it comes to these areas of study, but most college students are required to take at least one basic course in mathematics and one in science. Having a strategy to tackle the challenge of problem solving will get you closer to succeeding in these endeavors.

You could use this five-step approach to problem solving in math and science:

1. Read the problem and identify important information.
2. Recognize how this information is translated into scientific language or a specific mathematical formula.
3. Understand concepts, problems, and procedures by studying sample problems.
4. Take this information and apply it to practice problems. Experiment with sample problems or chapter questions.
5. Practice these steps until the material is mastered. Practice will help increase your speed while working out problems during an actual exam.

**Word Problems**

Math and science word problems tend to cause anxiety. For some reason, students seem intimidated by them, but this need not be the case. With a plan of action for solving word problems, students may become more proficient at completing them.

Suggested steps for solving word problems are outlined below.

* Determine what is to be calculated. Assign it a variable if necessary.
* Write down all the information given in the problem. Assign data to variables if necessary.
* If appropriate, draw a picture or diagram to illustrate the information given and the unknown. Clearly label all parts of the illustration.
* Write a formula to express the relationship between the known data and the unknown information. It often helps to write the formula in terms of variables at first. Then plug in the values of each known variable.
* Solve the problem.
* Check the answer.

(Source: Learning Strategies Database. Problem Solving. <http://www.muskingum.edu/~cal/database/general/problem.html> )

Resources:

1. Watch these informative videos on problem-solving strategies:
	* Frequent Solver Windows: [Windows Media](http://maclife.mcmaster.ca/academicskills/media/wmv/2006-ProblemSolving_I.wmv) | [mp3](http://maclife.mcmaster.ca/academicskills/media/mp3/2006-ProblemSolving_I.mp3) | [Quick Time](http://maclife.mcmaster.ca/academicskills/media/mov/2006-ProblemSolving_I.mov)
	* Concepts vs. plug and chug Windows: [Windows Media](http://maclife.mcmaster.ca/academicskills/media/wmv/2006-Understanding_%20vs.wmv) | [mp3](http://maclife.mcmaster.ca/academicskills/media/mp3/2006-Understanding_%20vs.mp3) | [Quick Time](http://maclife.mcmaster.ca/academicskills/media/mov/2006-Understanding_%20vs.mov)
2. Review and practice problem-solving exercises in these pages. Exams in this lesson will include problem-solving exercises.
	* <http://www.analyzemath.com/math_problems/math_problems_1.html>
	* <http://www.themathpage.com/alg/word-problems.htm>
	* <http://www.studygs.net/mathproblems.htm>

References

Paul, R. W. and Elder, L. (2002) Critical Thinking: Tools for Taking Charge of Your Professional and Personal Life. Published by Financial Times Prentice.

Paul, R. W. and Elder, L. (2007). Defining Critical Thinking. Retrieved April 3, 2011 from [www.criticalthinking.org/aboutCT/define\_critical\_thinking.cfm](http://www.criticalthinking.org/aboutCT/define_critical_thinking.cfm)

Ferret, S. (2010) Peak Performance: Success in College and Beyond. (7th ed.) McGraw-Hill: New York.

The National Foundation for Critical Thinking. (1987). Retrieved April 3, 2011 from <http://www.criticalthinking.org/about/nationalCouncil.cfm>

Videos on Concept Knowledge Maps and Problem Solving. Retrieved April 3, 2011 from <http://maclife.mcmaster.ca/academicskills/online_resources.cfm>