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Introduction

Why Are Critical Thinking Skills Necessary?

In order for a society to thrive, its citizens must be able to make observations, analyze the data gathered and make decisions. The businesses of our world rely upon their employees to think critically about multiple tasks and to develop solutions that will further the goals of business. Our American democracy anticipates that our citizenry listen to candidates and make voting decisions based upon their ability to analyze information. Our current political situation is a prime example of the need for critical thinking when participating in the electoral process. Even our family and social circles function more effectively when input is adequately critiqued and analyzed. Stability is enhanced under these optimal conditions (Shafersman, 1991). Howe (1989) further asserts that thinking critically is essential for individuals to live, work, and function effectively in our society.

It is important to distinguish between "critical" thinking, and thinking. The addition of this key term implies that it goes beyond the normal, survival mode of neurological pathways. Critical thinking skills are developed over time; they are not "natural" mechanism for survival. Individuals may be able to survive but will not prosper without critical thinking skills. The simple addition of the term critical indicates going beyond simple thinking skills to foster further capabilities that allow persons with this ability to progress beyond an average and flourish. This suggests that as teachers we must help to develop critical thinking in our students.

What is Critical Thinking?

Learning occurs on multiple levels. As we develop mentally, our learning skills progress from lower levels, such as memorization, to higher levels, such as critical thinking. Critical thinking carries the need to analyze, describe, model, and synthesize information (Ormrod, 2000). Many definitions have been set forth as to how critical thinking should be defined. Steven Shafersman (1991) defines it as: correct thinking in the pursuit of relevant and reliable knowledge about the world. Ellis Ormrod (2000) defines it as: evaluating information or arguments in terms of their accuracy and worth. Four key concepts, which consistently appear when defining critical thinking, are:

1) Content knowledge,
2) Procedural knowledge,
3) Metacognition
4) An attitude to use thinking skills and knowledge (Howe, 1989)

Critical thinking begins as individuals form questions based on observations they have made. As individuals gather data, hypotheses are formed, methods of testing those hypotheses are developed, and, finally, analyzing and systematically arranging data so as to lead one to conclusions. This process emulates what is commonly known as the scientific method. Shafersman suggests that the scientific method "is the most powerful method ever invented by humans to obtain relevant and reliable knowledge about nature" (1991).

Science Education Reform is of national interest, and its primary goal is to improve scientific literacy. This goal can only be achieved if our students are gaining knowledge about our world; using appropriate scientific principles when making decisions; engaging in debate and discussion about scientific matters; and increasing "their economic

productivity through the use of knowledge, understanding, and skills" (National Science Education Standards, 1996). If science education meets these standards, improved critical thinking skills are inevitable. Science education reform, if carried to its potential, will generate a society of thinkers capable of prospering in the 21st Century.

What strategies can be implemented?

It is imperative that strategies for improving critical thinking begin at the lower elementary levels and progress through high school and into college. I intend to primarily address the strategies of the high school student. However, in order to adequately dialogue about high school strategies, a brief discussion regarding elementary and middle grade strategies will introduce the section.

Elementary

It is imperative that elementary educators begin in the early grades with critical thinking exercises. According to Piaget's stages of cognitive development, children at the first grade level are beginning to develop concrete operational reasoning skills. They reason about concrete realities and begin developing adult-like logic skills. As long as students are given concrete information, they have the mental capabilities to develop and test hypothesis and demonstrate deductive reasoning skills (Ormrod, 2000). Teachers can assist the student by modeling positive behaviors and allowing students to explore.

The elementary classroom, therefore, must be filled with opportunities to investigate and explore. The student must be encouraged to hypothesize about the mechanisms that produce rain, to question the formation of dew, to attempt to explain why the sky is blue. These students must be given opportunities to express their ideas in a way that fosters creativity and thinking. Critical thinking coincides with creative thinking.

The elementary teacher should allow students the opportunity to do hands-on inquiry often, providing students with the freedom to develop their own projects. The student must learn to push through the content, to formulate ideas and to apply scientific methodology at an early age. The teacher should be cognizant of the value in allowing students to investigate a question without providing the answer. If we simply give students the answers and do not require them work for the solutions, we are creating lazy, rather than thinking students.

Middle Grades

According to Piaget, students at this level are developing formal operational cognitive skills. These students are capable of logical reasoning and applying it to more abstract concepts. They are capable of addressing multiple hypotheses and separating variables for manipulation. Students at this age can also make the transition from the concrete operational to the formal. They therefore need assistance in developing the more abstract concepts.

Teachers of middle grades should transition from content-focused to inquiry-focused teaching. Teachers should place students in states of disequilibrium. This state is believed to foster students to develop new ideas, and stimulate higher order thinking skills. If students are consistently being forced to take knowledge and apply it to new and unusual situations, their critical thinking skills will grow (Ormrod, 2000).

There should be a stronger development of the scientific method at this age group. The middle school student is capable of manipulating variables to observe outcomes. Students need to be given multiple situations in which they can devise hypotheses and test for their accuracy. Careful consideration should be given to reduce the amount of ìcookbook styleî research being done. The student should be encouraged to design research projects according to his/her own interests and knowledge of the material.

High School

As students enter high school, the majority is mentally capable of dealing with the abstract. They can manipulate multiple variables with multiple hypotheses simultaneously. They are using adult-like reasoning skills of induction and deduction. The high school student is capable of multiple and complex thinking tasks. If a student has

been challenged to think in the lower grades, he/she will be mentally adept at these complex skills in high school. However, if the lower grades have tended toward factual knowledge and limited thinking skills, the high school student will begin with a deficiency.

Critical thinking can be taught to high school students (and in similar ways to middle school students) during the following exercises: Didactic Lecture, Laboratories, Homework, Writing, and Exams (Schafersman, 1991). A specific discussion of strategies follows.

Didactic Lecture: This form of lecture provides both the teacher and the student a forum for dialogue and discussion. A key ingredients in science education reform is the goal of increasing the student's ability to discuss and debate scientific matters. During lecture, the student should be given ample time to ask and answer probing questions. The teacher should foster an environment in which questioning and critiquing the topic is encouraged. Students who ask questions are thinking. When a teacher encourages a classroom atmosphere in which the student is free to ask questions and to discuss issues, the teacher is more likely to produce students who think critically.

The teacher should ask tough and challenging questions during the lecture and allow the students plenty of time to offer solutions. The teacher should be cautious when giving answers because it can be counter-productive. If the students are given the freedom to discuss the question and converse with one another, they will be much more likely to learn and to remember the information, as well as to internalize the material. This proactive behavior on the part of the student will occur if the teacher is nurturing of such behavior.

Laboratories: Labs are scientific exercises that can engage a student in critical thinking activities. The teacher should attempt to deviate from traditional labs in which the students follow an algorithm for the desired answer as often as possible. This increases the amount of thinking involved and tends to improve the studentís understanding of the material. Labs should be open-ended, i.e., situations that allows the student to design the experiment. This will place the student in a state of disequilibrium and will force them to devise a solution (Ormrod, 2000).

Homework: It is an unfortunate fact that for some students and teachers, homework is misused to produce busy-work. If teachers will take the time to develop relevant homework assignments that encourages students to think and ponder on a given topic, homework can be a valuable tool to advance critical thinking. When students read journals, magazines and other literary works that relate to a lesson, they can better assimilate the information they acquire during the course.

Provide multi-step word problems for the Chemistry or Physics student. This type of activity requires that they first devise a hypothesis and then test it by working the problem. Mathematic word problems are ìessential to enhancing critical thinkingî (Schafersman, 1991).

Writing: There are few exercises that foster critical thinking better than writing. Individuals who write are forced to communicate their thoughts in a coherent and logical manner. They must acquire information, analyze it for value, arrange it systematically, present it logically and develop conclusions supported by their writing. Writing is a prime exercise for critical thinking and should be used as often as possible in the science classroom. Term Papers, Lab Reports, Essays, etc. any type of writing exercise that can be incorporated as homework or on test will help in the process of critical thinking development.

*Exams: Te*achers have the ability to improve critical thinking by developing proper test questions. Questions should not only require that the student simply memorize information, but that the student can apply the information in multiple ways. Exam questions should consist of multiple choice, drawings/diagrams, compare/contrast, essays, explain, describe, etc. When exams are structured in this way critical thinking skills are enhanced.

Implications for the Field

As educators, we have a tremendous opportunity to help parents shape the minds and lives of our society's future citizens. If we begin challenging our students to think critically, we will benefit from a more prosperous future. We must enhance our own critical thinking skills in order for us to adequately model for our students. Thinking students become thinking adults. As they enter and contribute to society, they will be able to make better analytic decisions.

Consider our present circumstance: Our society is littered with individuals who are mentally lazy, who rely on the members of "high society" to direct their decisions. Business moguls make millions on individuals who do not critically think about the ads pitched. Religious and social leaders sometimes teach what to think rather than how to think. The talking heads on our televisions screens are pushing an agenda that we adapt when we cannot critic the information offered. Government officials count upon uninformed and lazy thinkers when creating and delivering their rhetorical speeches. If we fail to train our students to become thinkers, we are perpetuating this cycle.

We cannot afford to sit back and allow our educational system to produce low functioning individuals. We must present them with knowledge and facts, while providing them with opportunities to think critically. The job of the educator should rest primarily upon their ability to develop these skills, rather than on how well students pass content-based tests.

In a recent television program, an aid to President Bill Clinton suggested that people would travel for miles through the desert searching for water, only to find that it was a mirage, and will drink the sand because they have no leadership. The President retorted that the people would drink the sand not because they have no leadership, but because they do not know the difference between the sand and water. If we fail to train our students to think critically, we will continue to see evidence of those who drink the sand because the do not know how to think for themselves.

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