

# Chapter 10

## Critical Thinking in Science and Technology: Importance, Rationale, and Strategies

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### ABSTRACT

*From as far back as the 1980s, many researchers have cited the importance of critical thinking in the citizens of modern societies. Given this importance, the merits of including critical thinking as a major objective at various levels of the education system and in different subject areas of the school curriculum have been extensively argued. This chapter focuses on science and technology curricula and rationalizes the need for changes both in the development as well as the implementation of the curriculum to facilitate the promotion of critical thinking skills in students. There is also an extensive discussion of particular instructional approaches and strategies needed to facilitate this.*

### INTRODUCTION

This chapter will trace the development of critical thinking perspectives as occurring in tandem with the development of scientific inquiry from the time of the ancient Greek philosophers. Arguments will be raised that the development of human civilizations required critical thinking even from the earliest human beings. However, with the growth of the scientific enterprise, that thinking was targeted at making sense of natural phenomena as well as altering nature for the benefit of mankind and human civilizations. This way of thinking was formalized in different subject areas in schools and universities. The growth of science and technology, the consequent changes in society, and the impact of that growth on ordinary citizens meant that there was increasing need for higher order thinking skills among human populations. A response was called from the education systems around the world. However, evidence will be highlighted that despite the presence of critical thinking as a goal of many curriculum documents around the world, this has not translated to the kinds of critical thinking required in the general

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population. The chapter will focus on these responses with particular reference to science education. Arguments are raised for the need for curriculum changes as well as instructional changes in science if the goal of a critical thinking human population is to be realized.

## **BACKGROUND**

### **Critical Thinking: Origins, Definition, and Relevance to The Growth of The Scientific Enterprise**

As can probably be expected, there is no consensus in the research literature as to what exactly is critical thinking. Many definitions allude to some generalized thinking skills required for a person to think critically. These include reflective thinking and purposeful, self-regulated judgment (Facione, 2011), and skilful conceptualizing, applying, analysing, synthesizing and/or evaluating information (Paul and Elder, 2004). Facione (2011) also identified the habits of mind of an ideal critical thinker which includes being habitually inquisitive, well informed, open-minded, flexible, prudent in making judgments, and persistent in seeking results which are as precise as the subject of inquiry permit. This seems to be a mouthful, but it may only be the proverbial 'tip of the iceberg' as to all the intricacies of the thinking and habits of mind of a critical thinker. Therefore, for this discussion, a simplified definition by Halpern (2007) is used where critical thinking is referred to as that which requires higher order thinking skills that are relatively complex, and involve judgment, analysis and synthesis of information, and are not applied in a rote or mechanical manner.

Why then is critical thinking regarded by so many philosophers, researchers and educators as important to individuals in modern societies? To understand this, we probably need to go back to what one may consider to be the likely origins of critical thinking. Though authors such as Sternberg (1986) point to the ancient Greek philosophers such as Plato and Aristotle as the initial proponents of critical thinking, it can also be argued that critical thinking is at least as old as human beings. By simply imagining what it took for early man to survive the harshness of earth's environment, it can be reasoned out that a great deal of higher order thinking must have taken place. The inventions of agricultural tools, the wheel, clothing, and the shaping of metals were all done long before the pronouncements of the ancient Greeks. These, and many other inventions, were the result of the thinking of human beings on how to use their physical environment to survive and improve on their way of existence. It can also reasonably be concluded that all the thinking skills and habits of mind identified as constituting critical thinking, did come into play in the process of coming up with these inventions.

Sternberg's (1986) reference to the ancient Greek philosophers as the original proponents of critical thinking is likely due to the historical records that highlight in fair detail the thinking processes involved in their efforts to explain natural phenomena. At that time, it was common for populations in Europe, and indeed around the known world, to ascribe the natural events (both good and bad) affecting them to supernatural forces for example the Greek and Roman gods. According to Wilson (1996), these philosophers relied on careful observation, logic, reasoning, and rational argument to propose natural causes for natural events. A distinction can clearly be seen between this critical thinking of these philosophers and the passive thinking of the 'common people' who simply accepted many important happenings in their lives as the will of the gods, or other supernatural entity. The simple acceptance of these occurrences meant that there was little effort at careful observation, questioning, and objective analysis aimed at

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