Chapter 64
Self-Regulated Learning as a Method to Develop Scientific Thinking

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ABSTRACT

The development of skills and the rationale behind scientific thinking has been a major goal of science education. Research has shown merit in teaching the nature of science explicitly and reflectively. In this chapter, the authors discuss how research in a self-regulated learning theory has furthered this finding. Self-regulation frames student learning as cycling through three phases: forethought (cognitive processes that prepare the learner for learning such as goal setting), performance (employment of strategies and self-monitoring of progress), and self-reflection (evaluation of performance with the goal). Because students have little interaction with the inherent guidelines that drive the scientific enterprise, setting goals toward more sophisticated scientific thinking is difficult for them. However, teachers can help students set goals for scientific thinking by being explicit about how scientists and science function. In this way, teachers also explicitly set a standard against which students can self-monitor their performance during the learning and self-evaluate their success after the learning. In addition to summarizing the research on learning and teaching of self-regulation and scientific thinking, this chapter offers recommendations to reform science teaching from the field of educational psychology.

INTRODUCTION

Learning how to think scientifically is important for an informed citizenry. In this era of information exchange and connectedness, knowledge continues to grow in an exponential way and technology fortifies this progress. Students graduating from K-12 schools must have the skills and knowledge to be independent learners, which includes the ability to think scientifically. Although it is important to generate students who are interested in pursuing science as a career, we also must be mindful that all students will be making future decisions based in science for their community. Therefore it is imperative that all students are scientifically literate when they leave formal schooling. However,

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there are still many unresolved issues regarding teaching students to understand science as a way of knowing effectively.

The purpose of this chapter is to present a literature review of the methods used to teach the nature of science in the classroom with particular emphasis on explicit and reflective approaches. Additionally, this chapter will address the parallels found between science education literature on explicit and reflective approaches and processes found in self-regulated learning theory. Because self-regulated learning theory has more articulated processes of learning that are not currently described in science education, adoption of a self-regulation oriented framework to study explicit and reflective teaching of the nature of science affords clearer methods of measuring learning. Empirical studies that have used self-regulated learning theory to teach the nature of science using explicit and reflective approaches are presented, and recommendations are made for future work in teaching the nature of science.

THE ROLE OF SCIENTIFIC THINKING IN SCIENCE EDUCATION

Scientific literacy contains two components: scientific knowledge and knowledge about the scientific discipline (Duschl, 1990). Scientific knowledge is the body of information that is factual and content-based. Knowledge about the scientific discipline is considered the methods that generate and validate scientific knowledge, which are the inherent guidelines that scientists use to ensure that the information that is generated from their scientific activities are valid and reliable (Lederman, 1992). In a standards-based and high-stakes testing environment, scientific knowledge is given priority, with little or no time left for teaching about the scientific discipline and knowledge validation strategies. A focus on static, factual knowledge results in a lack of understanding of how that knowledge comes about, and little understanding of what it is to be a scientist (Tobin & McRobbie, 1997). Without knowledge of the basic guidelines regarding the dependence of the scientific enterprise on characteristics such as rationality, precision of language, and attempts to limit bias as a standard for understanding the world around them, one must depend on other forms of knowing, such as tradition or instinct. Although ways of knowing such as instinct and tradition create a well-rounded human being, thinking scientifically is vital in making rational decisions. The famous physicist, Richard Feynman is attributed the quote, "Philosophy of science is about as useful to scientists as ornithology is to birds." Ignoring that birds do not have the cognitive capacity to understand ornithology, there are two reasons to disagree with this statement:

1. Thinking is more powerful when the execution of the thinking is apparent to the thinker; and
2. Philosophy of science should be taught in science classes so that the learners who may not consider themselves to be "science-minded" have a grasp of the guidelines for knowledge generation.

Scientific thinking skills have been advocated as an important component of science education because they provide a framework on which the students can incorporate content knowledge (Duschl, 1990; Lederman, 1992; McComas, Almazroa, & Clough, 1998; Parkinson, 2004, Peters, 2006; Turner, 2000). Learning the nature of science should not take the place of learning science content, rather they should be taught simultaneously. Students who have a deep understanding of the nature of a scientific endeavor can use this knowledge to create more scientifically valid content knowledge (Akerson & Abd-El-Khalick, 2003; Crawford, 2005; Duschl, 1990). When knowledge generation guidelines are hidden, then they may not even be agreed upon or apparent to all involved. Knowledge is most powerful when

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