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

Erin E. Peters Burton
George Mason University, USA

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,
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 paral-
lels 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 articu-
lated 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 gener-
ated 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 under-
standing 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 execu-
tion 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 stu-
dents 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 simultane-
ously. 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