In studying science, many elementary and secondary students learn the subject as a collection of facts and gain little or no understanding of science as a discipline. However, research shows that it is difficult for teachers to transfer their knowledge of the nature of science into explicit lesson plans. As a result of experiencing lessons based on the self-regulation intervention in this study, students are expected to make choices and produce ideas in scientific inquiry, reflect on their choices and ideas, check their reasoning against established ways of knowing in science, and make adjustments when necessary.

### Empirical Outcomes

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<th>Themes</th>
<th>Evidence</th>
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| Increase in content knowledge as a result of exposure to content-free prompts | Experimental group significantly outperform comparison groups in content knowledge and nature of science knowledge  
  ANCOVA in pre– and post-testing situation |
| Girls exposed to metacognitive prompts tend to see science as a human endeavor | Experimental girls vastly outperformed experimental boys in content and nature of science. Experimental girls reported a new understanding of the collaboration needed in science. |
| Reliance on and respect for evidence in science inquiry | When confronted with diverging conclusions, the experimental groups recreated the activity to find an answer. The comparison groups relied on peer pressure or waited for a teacher-led answer. |
| Change in study habits for assessments in science | Students in the experimental group report that they study diagrams, graphs and results from labs as well as their text, while comparison groups study vocabulary words |

### Conceptual Framework

**Self-Regulated Learning**

**Performance phase**
- Applying knowledge of process and content to new inquiry problem and self-monitoring

**Forethought phase**
- Organizing what is known about the inquiry problem

**Science Content**

**Self-Reflection phase**
- Checking outcomes for alignment to aspects of the nature of science

**Science Processes**
- Incorporation of nature of science into content

**Nature of Science Knowledge**
- Metacognition
- Self-Regulation

**Metacognitive Prompts**

- Incorporation of nature of science into content
- Student prior knowledge that is activated
- Student outcomes of inquiry

Adapted from Zimmerman (2000)

### Scaffolding Metacognition

**Observation**
- Students are given an exemplary model of the science task they are expected to master

**Emulation**
- Students attempt a similar science task as the model with support. The support is in the form of checklist items. Students compare their performance with a guidelines aligned with the scientific profession.

**Self-Control**
- Students attempt another similar science task as support is faded. Students receive a short checklist and questions for them to communicate rationale for decisions

**Self-Regulation**
- Students display their ability to independently perform the task. They are asked questions to justify their decisions and explain why they are aligned with the guidelines for the scientific enterprise.

Correspondence to: Erin E. Peters; Email: epeters1@gmu.edu