Learning science helps children develop an understanding of the world around them. To do this, they must develop concepts that help them link their experiences together and learn ways to collect and organize information and apply and test ideas. This learning not only contributes to children’s ability to make better sense of things around them, but also prepares them to deal more effectively with wider decision making and problem solving in their lives. When literacy skills are linked to science content, students have a personal, practical motivation to master language as a tool that can help them answer their questions about the world around them. Language becomes the primary avenue that students use to arrive at scientific understanding. Scientific literacy should emphasize scientific ways of knowing and the process of thinking critically and creatively about the natural world.

The Learning Research and Development Center at the University of Pittsburgh and the National Center on Education and the Economy identifies reciprocal skills associated with science and literacy (2000). These reciprocal skills include the following:

<table>
<thead>
<tr>
<th><strong>Literacy</strong></th>
<th><strong>Science</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>note details</td>
<td>observe and retain minute details</td>
</tr>
<tr>
<td>compare and contrast</td>
<td>how are things different and how are they the same</td>
</tr>
<tr>
<td>predict</td>
<td>what will happen next</td>
</tr>
<tr>
<td>sequence of events</td>
<td>process of logic and analysis</td>
</tr>
<tr>
<td>link cause and effect</td>
<td>what causes things to react in a particular way</td>
</tr>
<tr>
<td>distinguish fact from opinion</td>
<td>the use of evidence to support claims</td>
</tr>
<tr>
<td>link words with precise meanings</td>
<td>develop operational definitions of a concept through experiences</td>
</tr>
<tr>
<td>make inferences</td>
<td>based on observation and evidence</td>
</tr>
<tr>
<td>draw conclusions</td>
<td>by combining data from various sources</td>
</tr>
</tbody>
</table>

“When literacy skills are linked to science content, students have a personal, practical motivation to master language.”

Dr. Michael P. Klentschy  
Superintendent  
El Centro Elementary School District  
El Centro, California
This analysis of the reciprocal nature of science and literacy strengthens the view that effective science teaching is a powerful means to connect science and literacy.

This form of communication is both oral and written in the form of student science notebooks. Words and language are used as a way of trying out a framework for understanding—learners need to have to reflect on ideas. Through writing, students can generate a personal response to experiences for clarifying ideas and for constructing knowledge. Writing enables the learner to understand first and to communicate second.

Science and literacy also have another strong point of connection through the desire of many educators to develop metacognitive awareness in children. Cognition is an interactive-constructive process and metacognition is a conscious awareness and control of this process that results in verifying, rethinking, reflecting, and reshaping information into meaningful knowledge networks. Research has demonstrated that children can be taught these strategies, including the ability to predict outcomes, explain oneself in order to improve understanding, and to plan ahead. Teaching metacognitive strategies in context has been shown to improve student content understanding, written composition and problem solving, especially when language skills and science are taught in the context of each other (National Research Council, 1999).

**Student Science Notebooks**

The design of an effective program of instruction links science and literacy through the use of student science notebooks. An effective program of science instruction is based on the belief that students need to be provided with an opportunity to develop “voice” in their personal construction of meaning of the science phenomena. This voice comes in the form of their science notebooks. The science notebook is utilized during their science experiences, in social interactions, as a tool for reflection, and as a tool for constructing meaning (Klentschy and Molina-De La Torre, 2004). All students participating in effective programs of instruction in science showed a pattern of significant growth in student achievement in both science achievement and in reading and writing achievement (Amaral et al, 2002; Jorgenson and Vanosdall, 2002). This research also indicates that writing enables students to express their current ideas about science content in a form that they can examine and think about. Achievement in science is directly proportional to the student’s ability to use language (Fellows, 1994).

This form of expository writing through the use of student science notebooks may also help students link new information with prior knowledge (Rivard, 1994). Science notebooks can also contain drawings, tables, or graphs that are essential for the child to form meaning from the science experience. The use of student science notebooks in class discussions helps students construct meaning of the science phenomena. The student science notebook then becomes more than a record of data that students collect, facts they learn, and procedures they conduct. The science notebook also becomes a record of students’ reflections, questions, speculations, decisions, and conclusions all focused on the science
phenomena. As such, a science notebook becomes a central place where language, data, and experience operate jointly to form meaning for the student.

**Knowledge-Transforming**

By its very nature, the act of writing may enhance thinking. Writing may achieve this by demanding the learner to organize language. Frequently, classroom writing in science is directed at communicating what the student knows to the teacher, filling in the blanks or producing short responses to teacher-generated questions, and recording observations and information. Simply listing the procedures for experiments and writing a narrative of the results limits students in the construction of true meaning from the phenomena and reduces the experience to retelling knowledge.

The use of student science notebooks is effective for most students when the teacher is more concerned with establishing a dialogue with students to monitor learning, emphasizing the thinking and learning processes involved in learning the content. Teachers should consider posing questions that students might ask themselves in knowledge-transforming writing in their science notebooks such as:

- **What evidence do I have?**
- **What claims should I make?**
- **What are alternative explanations?**

Santa and Havens (1991) suggested that meaningful writing should bridge new information and prior knowledge, provide authentic authoring tasks for an uninformed audience, encourage minds-on learning, facilitate conceptual organization and restructuring, and promote metacognition. Writing should allow the transformation of vague ideas to clear conceptions and stimulate the construction of meaning. This belief is also based on the importance of establishing student “voice” in science notebook writing.

Marzano (1991) has argued that fostering higher-order thinking demands instructional activities in which the learner’s existing knowledge is restructured through activities that are complex and long term. He argues that writing is appropriate to induce knowledge transformation.

**Feedback**

One of the most important strategies a teacher can use is to provide students with feedback on their work. Teacher feedback plays an important role in the knowledge-transformational process of using student notebooks in science instruction. Marzano et al (2001) reported in a review of nine research studies that feedback that guides students rather than merely telling them what is right or wrong could show significant differences in student achievement. The most appropriate form of feedback in a knowledge-transforming mode of instruction is one of asking guiding questions to the student or writing guiding questions in their science notebooks.

The timing of feedback also appears to be critical to its effectiveness. In general, the more delay that occurs in giving feedback, the longer it takes students to

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eliminate misconceptions (Marzano et al, 2001). Perhaps this is especially true for science misconceptions.

Research on feedback also indicates that students can effectively monitor their own progress. The use of student feedback in the form of self-evaluation has been strongly advocated by researcher Grant Wiggins (1993). This self-evaluating form of feedback is also important in the construction of meaning by the students.

**Summary**

A growing body of evidence indicates that student participation in effective inquiry-based science instruction programs improves not only achievement in science, but also in reading, language arts, and mathematics (Amaral et al, 2002, Jorgenson and Vanosdall, 2002). An extensive examination of this body of evidence indicates a strong connection between science and literacy. The disciplines are mutually reinforcing in a reciprocating process. This connection appears to be the strongest where student science notebooks play a pivotal role in the instructional program. This connection also has the potential to assist students in developing their metacognitive abilities in science.

The student science notebook serves as the important link between science and literacy when used in the classroom as a knowledge-transforming form of writing. It provides the appropriate opportunity for students to develop “voice” in the process of constructing meaning from their experiences with the science phenomena. Coupled with appropriate and timely feedback from the classroom teacher, the science notebook has strong potential to provide the improvement in student achievement educators are seeking.

**REFERENCES (continued)**


