(Note: This paper was produced jointly by SCCAO and STAO in June 2005 with terminology that was accurate at that time. Future versions of this position paper will incorporate current Ministry of Education terminology.)

Literacy Through Science and Technology (K-8) and Science (9-12)

A Position Paper

The Science Co-ordinators' and Consultants' Association of Ontario (SCCAO)
The Science Teachers' Association of Ontario (STAO)

Abstract

Literacy skills are critical to student success in school. Yet, literacy is not achieved through literature alone. Being able to read carefully, think critically, and communicate clearly in the content areas requires skills and experiences unique to those content areas. This position paper calls on educators and decision makers to acknowledge the unique opportunities that scientific inquiry and technological design provide for enhancing student literacy skills. Furthermore, it provides a voice that all educators can use to promote the skills of scientific inquiry and technological design as foundational to a kind of literacy development unavailable elsewhere in the curriculum.

Background

Literacy has been defined as "the ability to use language and images in rich and varied forms to read, write, listen, speak, view, represent, and think critically about ideas"[1]. Literacy then is the ability to read critically and communicate clearly in the language, structure, and symbols of the discipline. It is essential that students are provided numerous opportunities and considerable support in developing and enhancing literacy skills that are central to the language used in specific content areas.

Purpose of the position paper

The purpose of this paper is to advocate for explicit literacy instruction within a science[2] framework. In science the enhancement of literacy skills must be centred on the skills of

[1] *Think Literacy Success, Grades 7-12, The Report of the Expert Panel on Students at Risk in Ontario*, Ontario Ministry of Education, Toronto, 2003.

[2] Science, for the purpose of this paper, refers to the elementary Science and Technology curriculum and to the secondary Science curriculum.

scientific inquiry (experimentation and research) and technological design. Teaching literacy skills through science is not synonymous with teaching science through a literature-based approach. It has been the experience of SCCAO and STAO that with the emphasis on "literacy", teachers who are intimidated by science and technology may attempt to cover curriculum expectations largely through print, video, and electronic resources. Although these certainly have their place, if students are to be able to communicate clearly about scientific and technological inquiries, they must be given numerous opportunities to conduct research, design experiments, and solve technological challenges appropriate to their grade level. Relying solely on print and electronic resources results in a language program about scientific topics, *not* in a science program.

Science consists not only of a body of knowledge, but of a way of pursuing and verifying that knowledge. That "way of pursuing" cannot be experienced vicariously; students must participate in the "doing" of science. It is through doing science that students will be provided with reasons to read critically and communicate clearly, both orally and in writing. Rich tasks that involve investigation, experimentation, and/or technical design are critical in providing opportunities for rich communication which, in turn, results in enhanced literacy skills.

Science and the elements of literacy

Reading

"Reading science text and textbooks requires the same critical thinking, analysis, and active engagement as performing hands-on science activities."[3]

The nature of science and scientific inquiry is unique; reading in science needs to reflect this. Since all literacy is context-dependent, it must be recognized that reading in science offers unique challenges that require students to use a wide range of skills:

- using of prior knowledge
- understanding and development of specialized vocabulary, units and symbols
- interpreting diagrams, data tables, charts, graphs, and other graphic tools
- using inference and reasoning
- recognizing concept flow and connection between concepts
- evaluating, comparing, identifying patterns, summarizing and forming conclusions
- navigating a variety of texts (e.g., websites, signs, labels, manuals, textbooks) and structures (e.g., table of contents, index, multi-format pages)

Scientific inquiry and reading in science should be interdependent. The two must be active, challenging and level-dependent, and involve frequent opportunities for practice and development.

Traditionally, students have not been taught the unique aspects of reading in science and the reading strategies for understanding informational text. An acknowledgement that science reading involves definite, identifiable skills means that science reading must be a formal component of effective science teaching and learning. Varied, purposeful and explicit teaching strategies – before, during, and after reading – must be used with appropriate assessment and evaluation tools. It should be a goal for students not only to

[3] Barton, M.L. & Jordan, D.L. (2001). *Teaching Reading in Science*. Aurora: McREL.

develop effective reading strategies, but to understand how and when to use them.

Writing

Writing in science, like reading, requires specific skills, direct teaching and time for students to practice and receive feedback prior to evaluation. Teacher direction and time to practice are often provided through teacher modelling (e.g., informal and formal laboratory reports, labelled diagrams, and templates or strategies for sentence, paragraph and essay writing). Traditional science writing should be enhanced through increased variety of opportunities, for example:

use of pre-writing activities aligned to specific methods of inquiry and to learning styles

continued and expanded use of direct instruction of informational text forms (e.g., expository writing, reports, letters, opinion paragraphs)

classroom environments that prominently display "reading, writing, and vocabulary resources [such as] key words, graphic organizers, examples of informational paragraphs … and general connectives"[4]

writing assignments that provide assessment opportunities for other curriculum areas in addition to science

use of non-traditional writing activities to communicate student knowledge and understanding

Writing instruction in science involves specific skill sets and text forms and, like reading, must be a formal component of effective science teaching and learning. However, it is the hands-on nature of scientific investigation and technological design that can provide writers at all levels with a reason to write.

Oral communication

Oral language plays a pivotal role in the development of all literacy skills, and is a foundational component of a comprehensive reading and writing program. In science, students use oral language to describe, share and present their investigations in both formal and informal contexts. However, the language of science includes special terms that are recognized as belonging to primarily these fields as well as words that in the context of science are used in new or distinctive ways. Terminology used in texts can be challenging for students. Introducing vocabulary carelessly or too soon may result in ample vocabulary but only cosmetic understanding of the terms for students. Students must be provided with ample opportunities to talk about science, using the language of science, so that science may be understood. If a word is in a student's oral vocabulary, it is easier to decode and understand its meaning in print. Hence, the form, content and use of oral language must be examined before making the transition to reading or writing. Teachers should scaffold the development of literate science (classroom) language skills in order to support the transition to literate language.

Direct vocabulary instruction will help students:

- increase reading comprehension
- improve writing skills
- develop knowledge of new concepts
- communicate more effectively, and

[4] *Supporting Student Success in Literacy Grades 7-12, Effective Practices of Ontario School Boards,* Ontario Ministry of Education, Toronto, 2004.

- develop deeper understanding of words

Teachers may employ a variety of strategies to teach essential oral language skills. These might include:

- phonemic awareness, phonics and word study
- word wall games
- word sorting
- shared/guided reading
- independent reading - to name a few.

Weaker students often focus on an entire word. Consequently, direct instruction on the analysis of word parts, including roots, suffixes and prefixes can help students recognize and process word chunks.

Visual communication

If literacy can be defined as the ability to use language and images in varied forms to read, write, listen, speak, view, represent, and think critically[5], then students must be taught how to understand graphical text in science. For example, students in grade 1 might use diagrams from big books to gain knowledge about caring for plants and animals; a grade 4 student may design, draw and label a simple structure/mechanism and explain how it works; in grade 9 a student may analyze a circuit diagram using Ohm's Law to explain the variation in potential difference across several loads. The process of scientific inquiry utilizes many types of graphical text that require skills in thinking and communicating beyond the written word.

Students need to be able to read and interpret information presented in unfamiliar ways:

not only left to right but right to left (number lines), top to bottom (data tables), diagonally (graphs) and circular (cycles).
symbols (e.g., Workplace Hazardous Materials Information System, WHMIS)
discipline-specific "language" (e.g., chemical nomenclature)
labelled and non-labelled diagrams
flow charts and visual organizers
equations and laws that must be applied to word problems
illustrations and photographs
models

Research has shown that by combining visual images with written text, students are better able to remember what they read. By reading and writing information in graphs, charts, diagrams, students process and comprehend that information at higher-order thinking levels. Current collections of science resources will contain all or most of these types of graphical text. However, they may not be used properly by students unless teachers demonstrate how these visual text forms can be used effectively. The use of oral communication then becomes critical as student explanations are guided by good questions from the teacher. Students' visual communication skills are based on prior experience and will become increasingly complex as they move through the grades. Explicit instruction is needed to support such skill development.

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[5] *Literacy for Learning: The Report of the Expert Panel on Literacy in Grades 4 to 6 in Ontario,* Queens Printer for Ontario, 2004 (page 5)

Summary

"Students thrive in an environment that is safe, engaging, organized, interactive, flexible, intellectually challenging, highly supportive and rich in texts of all types".[6] Explicit instruction in the areas of reading, writing, oral, and visual communication support such an environment. Similarly, "literacy instruction must be embedded across the curriculum. All teachers of all subjects, from Kindergarten to Grade 12, are teachers of literacy."[7] Improving literacy skills through active involvement in science enables students to better understand and communicate with and about the world around them. To provide students with unique reasons to communicate, literacy development in science must remain rigorously connected to the 'hands-on/minds-on' nature of scientific inquiry and technological design.

Recommendations:

1. That all teachers of science address literacy skills using the hands-on scientific inquiry and technological design opportunities prescribed in the provincial curriculum.
2. That all teachers of science provide explicit instruction in reading, writing, oral and visual communication using text forms specific to science.
3. That the Ministry of Education, school boards, and subject/divisional associations continue to provide resource support and professional development for literacy enhancement within a science framework.

SCCAO is a provincial organization whose members and associates are individuals within school boards, universities, faculties of education and the Ministry of Education and Training who have responsibility for supervision of various aspects of science programming in schools from Junior Kindergarten to Grade 12. (http://www.sccao.org/)

STAO is a provincial organization of teachers who teach science at the secondary level and science and technology at the elementary level. STAO's mission statement is to encourage excellence in science education through leadership and service. (http://www.stao.org/)

[6] *Literacy for Learning: The Report of the Expert Panel on Literacy in Grades 4 to 6 in Ontario,* Queens Printer for Ontario, 2004 (page 21)

[7] *Think Literacy Success, Grades 7-12, The Report of the Expert Panel on Students at Risk in Ontario*, Ontario Ministry of Education, Toronto, 2003.