# Appendix 7: Scientific Communication

One of the primary skill thrusts of Grade 12 Chemistry is that of providing many opportunities for *scientific communication*. Some of these instances will mimic the behaviours, traditions, and organizational aspects of a *scientific community*. Others are intended to be more authentic and directly promote student-centred development of skills related to the unique demands of communicating scientific ideas and results effectively.

The following strategies can be used in the science classroom to communicate scientific information. For additional information about the strategies, see the following teacher resources:

- *Senior Years Science Teachers' Handbook* (Manitoba Education and Training), abbreviated as *SYSTH*
- *Senior 3 English Language Arts: A Foundation for Implementation* (Manitoba Education and Training), abbreviated as *Senior 3 ELA*

## Audience (Adaptation for)

Students adapt information, such as a paragraph in a textbook, for a different audience.

## Booklet, Brochure, Pamphlet

Students may present information they have obtained through research or investigation in the form of a booklet, brochure, or pamphlet. This medium is most effective if the information to be represented involves a series of individual steps or points, and includes diagrams or pictures. Students involved in graphic arts may consider this an effective means of communication.

## Cartoons

An individual scientific concept, rule (such as a safety rule), or law may be effectively communicated by a cartoon, an illustration, or a series of pictures.

## Charts

Information or results that show related tendencies or patterns may be presented best in an organized chart. A flow chart may allow the steps of a process to become more apparent.

## Concept Overview Frame (See *SYSTH* 11.25, 11.37)

After studying a concept, students may fill out a Concept Overview Frame. This will allow them to summarize what they have learned.

## Data Table

Data measured during the course of an investigation are often best organized in a data table. The data table should have a title, labelled rows and columns, and the correct units. It may include several trials and the average values, as well as the equations used (in variable form). The data table should be prepared before the experiment begins.

## Debates (See *SYSTH* 4.19)

Debates are effective in presenting divergent opinions and attitudes related to STSE issues. The debate usually draws on students' own positions on science-related social issues. Pro and con formats can be used to illustrate the main points and to create a dialectic within the debate. While the scenario is often make-believe, the debate provides a forum for personal commentary. Because students often hold debated opinions with greater personal conviction, the debate must be structured in a manner in which sensitivity to various points of view is accepted, if not agreed upon.

### Suggested Organization of Debates

1. Select two small balanced groups of students who support divergent and opposing views on a science-related social issue.
2. Provide or have students research background information.
3. Students on each side of the issue prepare and coordinate their evidence to avoid redundant arguments.
4. Select a moderator to monitor time and response to questions.
5. Remind students to listen to and respect divergent points of view. Discourage the notion that only one viewpoint is correct.

## Demonstrations

Demonstration of a technique or a procedure is an effective way to communicate an understanding of the process.

## Diagrams

Visual communication is often more effective than a written description. Labelled diagrams may be useful for showing equipment set-ups, cycles, and so on.

## Dramatic Presentations

Many creative students enjoy dramatizing the information to be presented (such as the history of science) in the form of a skit, a role-play, a play, or a movie. Students must be prepared to research appropriate materials before constructing the dramatic presentation, as this process may be time-consuming. Care must be taken to ensure that students concentrate on the scientific concepts and knowledge, not solely on the dramatization.

## Graphing

Representing data in graphical form helps make the relationship between variables more obvious.

- When planning the graph, students need to consider scale. They determine the maximum values for both axes and make the scale accordingly.
- Students label both the vertical and horizontal axes with the factors being graphed and indicate the units being used.
- If the points indicate a straight line, students may use a straight edge. If a line of best fit is required and calculated on the calculator, students need to represent their calculations accurately.
- In a sentence or two below the graph or within the analysis, students explain the implications or main point revealed by the representation.

## Historical Perspectives

Students communicate information from the perspective of an individual (scientist, layperson) in another time period. They may choose to write an article critiquing an idea that was controversial in its time (such as smallpox vaccination or the Earth's orbit). Students research information and reflect on their response. Variations include responding from a different age or cultural perspective.

## Inquiry or Research Paper Handbook (See *Senior 3 ELA* 4-270)

Working in groups, students produce a handbook outlining the various stages, processes, and strategies of the inquiry or research process. This handbook is then available as a reference during the course of study, and may be adapted or supplemented as required.

## Journals

A scientific journal is an effective way for students to record thoughts and ideas during the progression of learning. Teachers may ask students to reflect on and respond to particular questions, such as noting their thoughts on a current issue in the newspaper. Alternatively, students may record their thoughts and feelings as they read a certain piece of scientific literature.

## Learning Logs

Students keep an inquiry or research log throughout their inquiry or research project. In this log, students may collect various artifacts representing stages in the research process, as well as record anecdotes of the experience.

## Models

Students may create two- or thee-dimensional models of a particular concept, theory, or idea. This may involve the use of materials such as papier mâché or modelling clay.

### Multimedia Presentations

Students may choose to communicate their understanding through the use of PowerPoint software, a video, or other types of electronic media.

### Newspaper Articles

By writing as reporters from a particular period of a society's history, students may see different perspectives of a scientific issue or idea.

### Oral Presentations

Gaining ease, composure, and a public presence while speaking to an audience are skills developed over many years of schooling and extracurricular activity. At certain points in a student's experience, some growth is encouraged in the arena of public oracy. When oral presentations are compulsory for students, teachers are encouraged to exercise caution and discretion. Focusing on these situations as celebrations of learning that students have mastered promotes confidence and success in addressing peers publicly.

### Posters

The poster session at scientific meetings has long been a standard in scientific communication, and provides an alternative venue for the presentation of new results to the large-scale public lecture that is not able to engage at a personal level. In a poster presentation, there is ample opportunity to "get close" to the creators of the work, ask questions, point out interesting facets of their work, and offer suggestions for continued efforts.

### Presentation Software

Students may use presentation software, such as *PowerPoint*, to present their information. Students must determine which sounds and images are suitable, and enhance communication, as well as learn how to use the program's elements to unify their presentation.

### RAFT (Role-Audience-Format-Topic and Strong Verb) (See *SYSTH* 13.23 for Format)

The RAFT writing assignment is a portfolio strategy designed to produce creative and imaginative writing pieces in science. Through these assignments, students can

- see alternative perspectives on a science topic or issue
- uncover divergent applications of science concepts
- make connections between their world of experience and their science learning (e.g., metaphorical stories)

### Recommendation Report (See *Senior 3 ELA* 4-270)

Students write a short reflection on the implications of their inquiry findings. In their reflections, students may wish to

- identify subsequent inquiry topics that might grow out of the one they have researched
- suggest how the information gathered in the inquiry could be applied
- recommend action that should be taken to solve a problem
- explore how public awareness could be raised about an issue
- describe how they will think or act differently because of the inquiry

### Role-Playing (See *SYSTH* 4.18)

Role-playing scenarios teach selected social processes that govern relations, such as negotiation, bargaining, compromise, and sensitivity. Ultimately, students would use these skills as they move from vision to action in dealing with STSE issues. Role-playing often provides an avenue for presenting biased opinions, which may or may not agree with the opinions of students. Most importantly, it introduces divergent points of view and allows students to analyze and respond, thereby giving them an opportunity to gain an appreciation for why individuals hold divergent points of view. Ideally, the role-playing scenario fosters critical-thinking skills while promoting tolerance of other world views. All simulations have rules that govern human interaction. Regardless of the roles assumed, certain behaviours should be promoted, while others should not be allowed.

### Roundtable

A roundtable discussion should engage all students in open scientific discussion. The discussion may be initiated by concepts outlined in a scientific article. The opening question should engage all participants and should be based on the text of the article. Although it is not necessary, the teacher may ask *each* student to respond briefly to the first question to “break the ice.” (Examples of opening questions are: “What is the most important idea in this text? Why?” and “Do you think this text is scientifically valid? Why?”) The core question may be changed during the roundtable discussion to clarify a response or to refocus the group. This question should be focused more directly on the text. (For example: “Why did the scientists use [this animal, technique, equipment]?” or “Explain what the author meant by the word ______ in Paragraph 4.”) This question should encourage students to examine how their thinking has changed during the course of the roundtable discussion. The teacher may want to ask questions (such as “How have your answers to the opening question changed?” or “How does the topic relate to your lives?” or “What could be done next?” or “What would you change?”). These questions should not solicit answers to which everyone would agree.

- **Role of Teacher:** The teacher’s role is to facilitate, not validate. Try not to make any response, whether with a facial expression, nod, or frown, that would indicate a right or wrong answer. Ask questions that provoke and take thought to a new level. Remind students to back up thoughts with facts from the document. An idea might be to diagram the seating arrangement, “web” the responses, and add a word or phrase beside the name of the speaker. This strategy can help

- identify who speaks and how often
- provide cues to additional questions
- keep the teacher from physically affirming responses

If one student appears to monopolize the roundtable, each student may be issued five chips. Each time the student speaks, he or she gives up a chip. Therefore, the student has five opportunities to speak.

- **Role of Student:** Student participation (both speaking and listening) is mandatory. Students need to be courteous and respectful of classmates. They speak without raising their hands, talk to each other, and address the person they are speaking to by name. A roundtable is a way for students to communicate what they think about the document, not what they feel. They should always refer to the text.

### Scientific Paper (See *SYSTH* 14.13 for Format)

At the Senior Years, exposure to the writing of a technical, scientific "paper" is of utmost importance, but it should be treated in an introductory manner. Many students face the reading (or writing) of the scientific paper rather suddenly at the post-secondary level of study, and are ill-prepared for it. In reality, particular scientific journals have their own writing style, format, and so on. No single format or referencing style should be advocated exclusively, but exposure to a few examples is helpful (for instance, using an American Psychological Association [APA] style of referencing versus numerical endnotes).

In the *Senior Years Science Teachers' Handbook*, teachers are offered some standard, normative samples of the Laboratory Report Format and the Scientific Paper Format (see *SYSTH*, Chapter 14: Technical Writing in Science, 14.11 to 14.15). Keep in mind that one of the chief purposes of the classical scientific paper is to announce the results of research related to *new contributions* in a field. Consequently, its role and purposes are distinct from that of a research or position paper.

### Storyboard

Students could create storyboards to show the development of a scientific concept or theory. Discussion may then centre on the suggestion: "What might have happened if the order of occurrence had been changed?" (changing chronology)

### Web Page Creation (See *Senior 3 ELA* 4-168)

Stages of creating a website may include

- surveying other websites on the same subject
- compiling a list of criteria for an effective website on the chosen subject
- writing a proposal for the website, describing its intended audience and purpose
- using a flow chart for constructing a personal website or contributing to the school's website

## Word Cycle, Word Glossary (See *SYSTH* 10.21)

A Word Cycle is considered a Level 1 strategy in building a scientific vocabulary (for instance, see *SYSTH*, Chapter 10: Building a Scientific Vocabulary). The value in using a Word Cycle comes from taking a broad concept such as an ecosystem, providing a list of terms that could be related to that concept, and then asking students to link these words coherently. Students then learn how terminologies are related, broaden meaning of terms, and promote collaboration. Teachers are encouraged to use Word Cycle activities with their students in a cooperative manner (e.g., pairings).

A Word Glossary, steadily accumulated over time, is a useful way for students to organize the large number of terms that science topics bring forth. Pay close attention to the repetitive use of prefixes (e.g., neuro-) and suffixes (e.g., -logical) in scientific parlance.

## Written Lab Report (See *SYSTH* 11.38, 11.39, 14.12)

There are a variety of formats for lab reports within a common framework. A lab report may contain the following information:

- **Abstract/Introduction:** A condensed version of the entire paper, placed at the beginning of the report. The material in the abstract is written in the same order as it appears within the paper, and should include a sentence or two summarizing the highlights from each section. The abstract is written once the paper is complete.
- **Purpose/Objective/Problem:** A brief statement of the purpose or objective of the experiment.
- **Background Information:** Information drawn from research.
- **Pre-Lab Theory:** The posing of a theoretical solution to the problem before the experimental procedure. It may involve a conceptual explanation and mathematical calculations.
- **Hypothesis:** Contrary to the persistent myth, a hypothesis is not an "educated guess" about what will happen. A statement such as "cigarette smoking causes cancer" is a hypothesis because it is a statement of suggested behaviour in the material world that is *testable* by scientific means. A hypothesis intends to make a *contingent claim* based on prior accepted models about how the world works. The claim, then, is subject to testing over and over again. It is the task of the investigation procedure either to support or to nullify the hypothesis statement.
- **Variables:** For the purposes of this curriculum, anything that comes in different types or different amounts and could possibly enter into an investigation. The simplest sort of relationship to examine is that between two variables (e.g., a person's height and arm span). It is not always a simple task, however, to *control* all the variables that may confound a scientific investigation.
- **Materials:** A list of the materials to be used in the experiment and a labelled diagram of equipment set-up, if applicable.

- **Procedure:** Written step-by-step directions for performing the experiment and regulating the controls, and a summary of the steps taken, so that someone who has not performed this lab would be able to repeat it. If a mixture is heated, the temperature should be given. Any modifications to the procedure should be noted. When following a procedure from a secondary source, reference should be given for the source.
- **Results:** Include drawings, measurements, averages (if applicable), observations, data tables, calculations, and graphs.
- **Observations:** Qualitative interpretations of what is occurring during the course of an experiment. Examples include colour changes, odour, formation of a precipitate, release of gas, temperature differences, pressure changes, or changes in solubility.
- **Quantitative Data:** Measurements taken directly from laboratory instruments. Data must be collected with care during the experiment, properly identified, and the correct numerical values and units used. Suspected faulty data must be presented and explained in the conclusions if not used in the analysis.
- **Sample Problems:** Show the conversion of data into results. Calculations should be properly labelled, with the accuracy and precision of the instruments taken into consideration, and the correct number of significant figures used.
- **Analysis:** An important part of the report that demonstrates an understanding of the experiment. It contains an interpretation or explanation of results, indicating their significance, how accurate the original hypothesis was, sources of error and their effect on results. The analysis also indicates ways to improve the experiment, including modifying the procedure, the equipment, the variables, and so on. The analysis can relate results to the real world and may describe a follow-up or auxiliary experiment.
- **Conclusions:** A summary of results and whether the purpose of the experiment has been achieved. Readers often read the conclusion first.

### Zines (See *Senior 3 ELA* 4-166)

Zines (or fanzines, or mini-magazines) usually treat a particular theme. Components may include

- cartoon
- collage
- editorial
- interview
- memoir
- poem
- review
- survey results