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ABSTRACT

Designed to provide teachers with new knowledge about the goals of science instruction and practical recommendations for instructional practice, this first of a three part series of guidebooks specifically focuses on the topic of scientific literacy. The major objective of this guide is to introduce teachers to a working definition of scientific literacy and to support its importance in intermediate life science instruction. Ideas and inservice activities are discussed under the catagories of: (1) what is scientific literacy (explaining the five components of scientific literacy); (2) making good use of scientific literacy (reviewing methods and principles for integrating scientific literacy into the curriculum); (3) why is scientific literacy important (outlining the benefits of using scientific literacy goals); (4) summary (stating the objectives for the three guidebooks); and (5) recommended resources (including references from periodicals, books, and television). An appendix contains an additional example of the use of scientific literacy principles, training notes, and materials for overhead reproduction. (ML)

Secondary Science and Mathematics Improvement Program

WHAT IS SCIENTIFIC LITERACY?

A Guidebook for Teachers of Life Science at the Intermediate Level

Intermediate Life Science Study Series, Volume I

Far West Laboratory for Educational Research and Development

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PREFACE

This guidebook is the first of a series of teacher inservice materials produced by the Secondary Science and Mathematics Improvement (SSAMI) Program at the Far West Laboratory for Educational Research and Development. The goal of the SSAMI Program is to study and improve instruction in science and mathematics at the secondary level. During the 1983-1984 school year, one of the ongoing projects of SSAMI was the Intermediate Life Science Study. This guidebook -- and two to follow -- represents an effort to translate the background and findings of the Intermediate Life Science Study into a set of materials that provides teachers not only with new knowledge about the goals of science instruction and its current practice, but also with practical recommendations for moving each teacher's current practice closer to these goals. A set of training instructions, to be used in conjunction with each guidebook in workshop meetings, also is provided.

We wish to thank Dr. Virginia Koehler and Dr. John Taylor, Teaching and Learning Division, National Institute of Education, for their support in this and other work. Their interest in exploring innovative ways of approaching the problems that confront educators and their encouragement of educational excellence are appreciated.

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WHAT IS SCIENTIFIC LITERACY?

Background

With today's renewed focus on improving the education of our youth, science instruction is receiving its fair share of attention. Some of this attention is fueled by a concern that the United States maintain a large pool of scientists and, thus, its competitive position worldwide. There also is attention to the need for <u>all</u> citizens in our increasingly technological society to have a broad working knowledge of science -- to be <u>scientifically literate</u>. But what does being <u>scientifically literate</u> really mean?

> Take a few moments now to think about what the term "scientific literacy" means to you. What behaviors from students might indicate that they are scientifically literate?

The term "scientific literacy" was first used in the 1950's as a "rallying symbol" without any clear definition. By now, many science experts have given their own definition of scientific literacy. While the details of these definitions may vary from expert to expert, achieving <u>scientific literacy</u> is a goal that is highly valued by the majority of scientists and science education experts. However, being easier said than done, teaching students to be scientifically literate is a complex and challenging task for science teachers. Most current textbooks and supplementary materials are not good resources for scientific literacy and most teachers do not receive training regarding scientific literacy. Yet, through the initiative of teachers such as yourself, scientific literacy can become a regular part of science instruction. This guidebook was designed to help you take this initiative.

The Five Components of Scientific Literacy

Taking the many definitions together, we view scientific literacy as a framework consisting of five components:

1. Explaining the Content of Science.
2. Relating Content to the Social Historical Process of Science.
3. Relating Content to the Reasoning Process of Science.
4. Relating Content to the Societal Impact of Science.
5. Relating Content to the Personal Use of Science.

The first component deals with communicating the content (i.e., terms, facts, and concepts) of science. This has been the typical focus of science instruction. The remaining components are termed "relating" components. These components represent four different contexts for the content of science. In short, when presenting any particular topic in life science, it is possible to refer to one or more of these relating components to provide a larger context of meaning. This notion of providing a context of meaning will become clearer as you read along.

The relationship among the five components of scientific literacy is presented in Figure 1. This figure shows the central focus of Explaining the Content of Science. Each of the relating components is portrayed as a potential source for providing a context whereby the content of science can be learned and understood. Of course, in actual practice, you may find that there is a close connection among some of the relating components themselves; furthermore, certain science content topics may lend themselves more easily to a particular relating component than others.

Students' knowledge of science content and its relationship to the relating components can be fostered through several means. For example, most students probably pick up some understanding of scientific phenomena and the context for these phenomena through experiences outside of school -- whether by their own natural curiosity, visiting science museums, or by watching a science series on television. In school, when students take a science course, there are again numerous ways they may become scientifically literate. They may acquire scientific literacy through the textbooks that they read, by the assignments that they complete, by the films that they watch, by the activities that they participate in, and by what they hear in presentations made by you and guests.

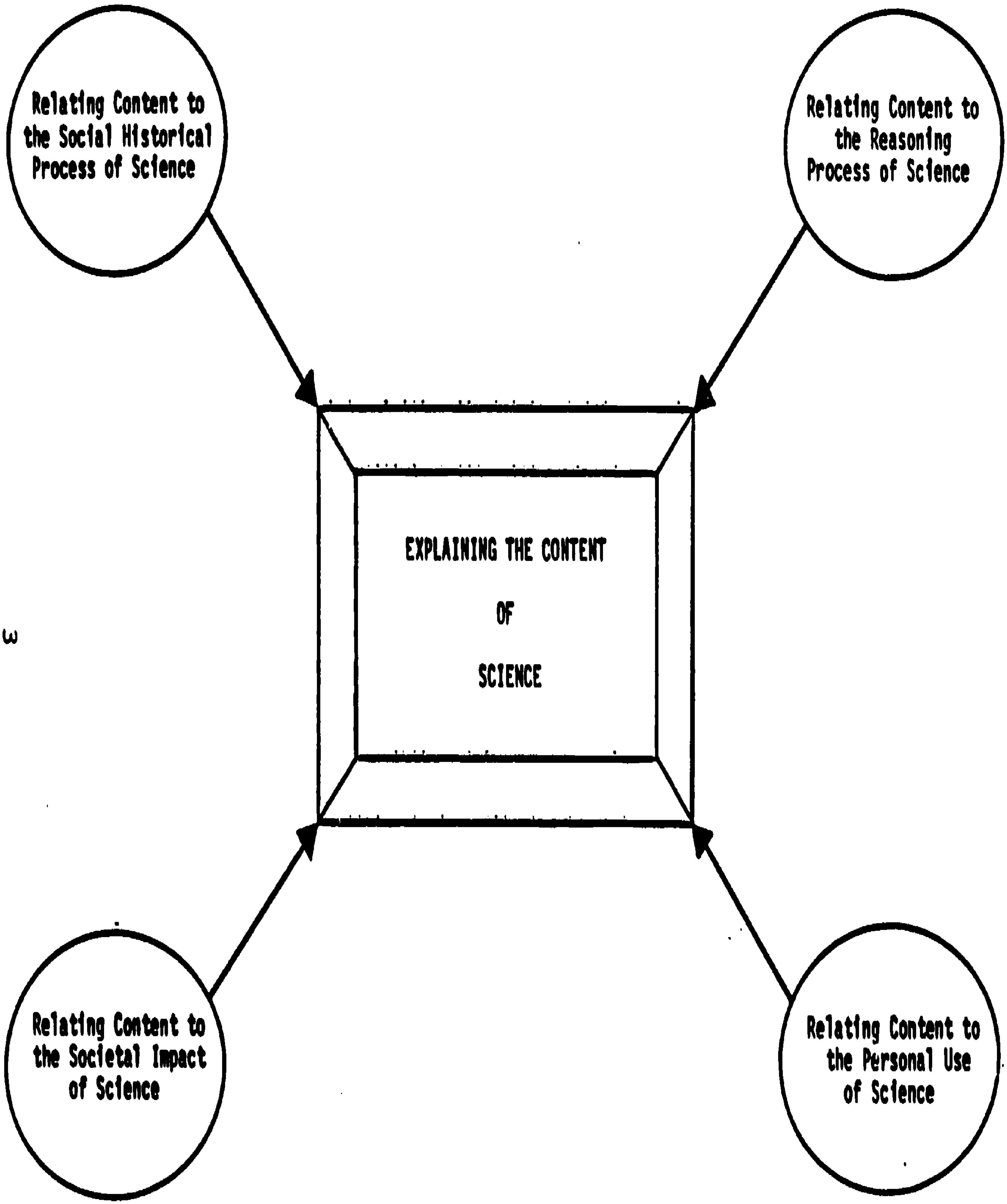

Figure 1. The Scientific Literacy Framework

In this pamphlet, we want to concentrate on discussing scientific literacy in terms of some ways that <u>you can foster it with your students</u>. Here it helps to think of those aspects of your classroom and teaching where you can exercise the most control. For example, you may not have much control over the selection of your main textbook and supplementary materials. Thus, if your current textbook does not systematically refer to the scientific literacy relating components, your textbook may not be a sufficient scientific literacy resource for you or your students.

In contrast, the presentations and work assignments that you give to your entire class are aspects of your instruction that you can shape to your goals. Thus, if you make a point to address the scientific literacy components in your presentations and work assignments, these presentations and assignments become important avenues by which your students can achieve scientific literacy.

After defining and illustrating the scientific literacy framework, we suggest some fruitful approaches for using it with your students. Then, we present some important reasons for using scientific literacy in the life science curriculum based on current research in the areas of psychology and education.

Let's reconsider, then, each of the five components of scientific literacy in terms of the kinds of steps you can take as a teacher to bring scientific literacy into your classroom:

Defining the Five Components of Scientific Literacy

<u>Explaining the Content of Science</u>

Terms, facts, and concepts are fundamental to specific life science topics. This basic content is the foundation for understanding many of the essential phenomena of earth's life systems. For example, if you are teaching students about the digestive system of mammals, the names and functions of several organs as well as the role of digestion are basic content you need to explain. Or, for a unit on the structure and function of cells, you would probably want students to become familiar with the names of the major single-celled animals and how they reproduce.

> Bring to mind now a topic (complete unit) that you are familiar with or that you particularly enjoy teaching. As each of the four relating components are defined in the following section, think how they might be relevant to that topic.

Relating Content to the Social Historical Process of Science

Scientific knowledge is not discovered as a set of preexisting facts; rather, it accumulates as the work of individual scientists. This work must be recognized and accepted by other scientists and the public at large. Often both the scientific community and public are slow to recognize and assimilate new theories and discoveries.

You can communicate this social historical process of science in specific or general terms. In specific terms, you can refer to the contributions of particular individuals in history and the way that their contributions to the existing body of knowledge take hold. For example, you could organize a topic on genetics by discussing the work of Mendel and how his scientific community reacted to his findings. In general terms, without mentioning specific scientists, you can frequently mention how some aspects of scientific knowledge are the collective work of many individuals working on similar problems, without mentioning specific scientists.

Relating Content to the Reasoning Process of Science

Scientific knowledge is also accumulated through a set of agreed upon methods and standards, and not in an arbitrary fashion. You are relating to this component when you take a topic and illustrate how you can learn about the topic by observing natural events and formulating and testing hypotheses. In the course of such a presentation, you may also have occasion to cover the concepts of deductive and inductive reasoning, randomness and probability, as well as the tools and methods of measurement.

Relating Content to the Societal Impact of Science

Scientific knowledge frequently leads to the development of new technologies that, in turn, influence society. When presenting a topic, you can often make a direct link between a related technological product (e.g., a new fertilizer) and its social consequences (e.g., more productive farming, increased land use, more pollution). This component lends itself especially well to the presentation of at least two points of view (e.g., the advantages and disadvantages of organ transplants), thus modeling parts of a decision-making process that students can apply in their role as citizens.

Relating Content to the Personal Use of Science

Clearly, what students know about science has implications for their everyday lives. Scientific knowledge in particular topic areas can help students make informed decisions about their own health and their selection of food, household goods, and sources of energy. By illustrating the personal relevance of science content, you can foster well-founded positive attitudes toward science as a discipline.

> Recall the topic you thought of earlier. Which of the relating component(s) could you use to help talk about that topic?

> Jot down now any questions you might have about the explaining or relating components of scientific literacy. We can turn to them later.

MAKING GOOD USE OF SCIENTIFIC LITERACY

Instructional Methods

There are several major instructional methods you can use to increase your students' understanding of the content of science (explaining component) and the four relating components. You can address any of the five components in your verbal presentations to students. This can occur through short statements or longer "lecture-like" talks. You also can encourage students' recognition of scientific literacy by writing key points on the board and by asking students to answer questions. Another technique is to get a discussion started among students about the connection between content and the relating components. Finally, you can give your students assignments that tap their memory and understanding of all aspects of scientific literacy.

While these are all good techniques, helping your students to become scientifically literate may require more than just referring to science content and the four relating components. You will become a more effective communicator of scientific literacy if you make scientific literacy one of your major instructional goals and systematically plan for how to include scientific literacy in each of your course topics. Also, keep in mind that while the connections between science content and the relating components may seem obvious to you, your experience gives you a much different perspective on the subject matter than that of your students. You have a crucial role in showing your students the connections.

Below are several principles for integrating scientific literacy into your curriculum and effectively addressing it in your presentations and assignments.

Principles for Using Scientific Literacy

1. Introduce your students to the scientific literacy framework at the beginning of the school year. As one of your first class activities, it is a good idea to give your students a presentation on "Why We Study Science," using this opportunity to explain the scientific literacy framework to them. A good way to do this may be to present one topic example (e.g., human systems) and show how topic content can be linked to each of the relating components. By familiarizing your students with the structure and meaning of the scientific literacy framework, you are increasing the likelihood that they will recognize and comprehend the connections you make between science content and the relating components. Also, you may be encouraging students to make their own connections to the relating components as they proceed through the course content.

2. Build up your own scientific literacy resource folder. An analysis of today's most popular intermediate life science textbooks indicates that they are devoted almost entirely to the explaining of science content, rarely making reference to any of the relating components. Thus, it probably will be necessary for you to compile your own set of scientific literacy resources. Here, the easiest approach is to set aside a special folder or notebook where you can place materials and ideas that are potentially relevant to the topics you already teach. If you place these materials and ideas in the folder as you come across them, you will have valuable help when you sit down to plan your topics.

3. Before you begin each topic, sit down and plan what parts of the scientific literacy framework you will use and how you will use them. Deciding how to make the connection between science content and the relating components requires some careful planning. For example, if you are planning to incorporate scientific literacy into a topic for the first time, you may have to locate some resources (e.g., other textbooks, magazine articles, the encyclopedia) in addition to your standard set of materials. These resources should help you decide which relating components you want to emphasize and which specific examples you want to use with your students. After you have decided on your emphasis and examples, you should outline your topic activities, indicating how you will use the relating components.

4. For each topic, focus on explaining content in the context of no more than two of the relating components. It is possible to have too much of a good thing. If you plan a topic so that you make repeated connections to all four relating components, you risk overwhelming and confusing your students. Thus, it is preferable to select one or two of the relating components as the primary theme(s) for organizing your topic content. While this does not mean that you should avoid making connections to other relating components, it does mean that during any one topic area, one or two relating components will receive more attention than the rest. If you are gearing your year's curriculum to the scientific literacy relating components for the first time, it may be best to limit yourself to only one relating theme for each topic. Further, it is advisable to select only some of your topics for revision.

5. When you use a relating component, be explicit. In other words, cue your students when you are using one of the relating components. Here, it is important for you to emphasize the language of the components when you talk to your students (e.g., "Now, let's stop and consider what this may mean for our current society"). As you use this language regularly, you can reinforce its purpose by referring students back to the scientific literacy framework. While a high level of explicitness may be difficult to achieve and requires a good deal of practice and planning, you will find that your students will be more likely to tune into explicit connections between content and the relating components.

6. When you use a relating component, be consistent. Whatever relating component(s) you select for your primary theme(s), it is important to carry the theme through the entire topic. This does not mean that you have to devote a large block of time to the relating component each day. Rather, it means that you should not let your students lose sight of the significance of the relating component as an organizing context for the topic content. Thus, on some days, you may provide longer examples based on the relating theme, while on other days you may simply refer back to these examples or give short ones. Note that this approach contrasts with simply giving occasional anecdotes during a topic. Because they are not generally part of a larger framework that you have previously identified, the sporadic use of anecdotes may actually confuse students rather than help them. Thus, being consistent, like being explicit, is facilitated by good planning and practice.

7. When you refer to the scientific literacy components in your presentations, reinforce students' understanding by asking them questions about the same components in class and on their assignments. When you give attention to the scientific literacy relating components in your presentations, you should check your students' comprehension of these components by asking them questions in class. Your questions should encourage students to state their own understanding of the connections between content and the components (as contrasted with having them simply answer "yes" or "no"). Including similar questions on your assignments is important because students perceive assignments as the clearest indicators of what you actually value as a teacher. (Performance on assignments usually is the largest contributor to their grades.) In other words, your students will pay little attention to the relating components in the long run unless you also design your assignments to reflect these components. Thus, you should design or revise your laboratory, worksheet, and exam materials to include items that ask for students' understanding and interpretation of your chosen scientific literacy theme(s).

Which of the above principles would be easiest for you to adopt in your particular situation? Which would be most difficult?

An Example of Making Good Use

<u>Principle #</u>

"Martha Curie" teaches intermediate life science. Her next topic is "bacteria, viruses, and disease." When Martha sits down to plan this topic, she notes that the relevant chapter in her intermediate life science textbook makes brief mention of Pasteur for his work supporting the theory that bacteria affects fermentation and can cause diseases. This leads Martha to consider the possibility of presenting the topic content on bacteria, viruses, and disease in terms of the work of several individual scientists (i.e. relating content to the social historical process of science).

2 - build up resource folder

4 - focus on no more than two

3 - plan before you begin topic

When Martha then turns to her scientific literacy and a few supplementary resource books, she finds that there are a number of folder historical events that can be used to give context to knowledge about bacteria, viruses, and disease. She decides to focus on one theme -- relating content to the social historical process of science -- as the major organizer for the topic. After some consideration, Martha outlines the following plan for herself:

- Introduce the topic with an overview of the beliefs past societies have held about contagious diseases (e.g., ancient Greece, Middle Ages, early 19th century). Emphasize that human disease, particularly the outbreak of various epidemics, was a major impetus for scientists to begin looking for the agents of disease. These agents turned out to be microorganisms. Two major categories of microorganisms are bacteria and viruses.

- Introduce and contrast the basic structures of bacteria and viruses. Compare both with the typical cell structure.

- Indicate that the current understanding of bacteria and viruses is the result of the work of many individuals, beginning in the 19th century. Take four individuals as examples and describe their work.

(a) John Snow's work (1850s) determining the manner in which cholera is spread. He theorized that this disease was caused by microorganisms, but his work did not confirm it.

Principle #

(b) Robert Koch's work (1870s) (also carried out elsewhere) isolating the bacteria causing anthrax and tuberculosis. Koch was able to observe the bacteria under the microscope (unlike Snow). Koch's unique contribution was to develop methods for studying bacterial growth in the laboratory.

(c) Louis Pasteur's work (1860s-1880s) on germ theory (refer back to topic where spontaneous generation was covered) and immunization. Pasteur took Koch's work further by developing a vaccine for anthrax. Also, he developed a vaccine for rabies, which is a virus. However, Pasteur did not realize that he was dealing with an organism distinct from bacteria.

(d) Viruses were not actually identified until the work of Frederick Twort. Twort was growing colonies of bacteria and found that something was destroying these colonies; thus, the first viruses discovered were those that attack bacteria.

o Go back and review the structure of bacteria and viruses, adding information about how they work to cause disease, and what makes them good disease agents in terms of resisting the body's defenses.

o Indicate that while some bacteria cause disease, many bacteria serve beneficial purposes. Cite examples. In contrast, viruses cannot be considered beneficial because they inevitably cause the destruction of cells. Nonetheless, viruses have greatly helped scientists to understand the operation of genes.

6 - be consistent with relating component

With this outline sketched out, Martha goes on to think about the kind of activities she can use to convey the above information and engage students in the topic. Martha decides to present the information initially in several recitations spaced throughout the week.

5 - be explicit with relating component

1 - introduce students to framework at beginning of year

At the beginning of the first recitation, she tells students directly that she will be presenting the topic in terms of a social historical setting, and she refers students back to the scientific literacy framework that she presented to them at the beginning of the year.

Principle #

7 - reinforce students' understanding by referring to components during in-class questions	During all her recitations, Martha makes a point to ask students questions to get them involved in the recitations. These questions tap students' comprehension of the material and their own knowledge of various diseases and their transmission.
7 - reinforce students' understanding by referring to components on assignments	In terms of assignments, Martha has several for the topic. First, she uses last year's worksheet that asks students to identify and label the structures of bacteria and viruses. She adds a couple of questions to the worksheet that ask students to consider the tools scientists needed to study these organisms and what led them to view these organisms as distinct from typical cells. Martha also gives students an entirely new worksheet that presents a set of factual data about a hypothetical disease and asks them to indicate what methods they would use to track and identify the disease agent. Martha notes that this is an opportunity to reinforce the social historical process of science if she also asks students to contrast their methods with those used by Snow and Koch. Martha thinks of designing her final exam in a similar fashion. Finally, Martha gives her students the extra-credit option of doing individual research reports on a bacteriologist or a disease that interests them.

In this example, Martha has provided her students with several interesting opportunities to become more scientifically literate (e.g., through recitation, worksheets, exams). Thanks to her resource folder, her text, a few additional materials, and her own good ideas, Martha found that it was useful and relatively easy to address the social-historical process of science as a backdrop for the topic, "bacteria, viruses, and disease". By following the above principles, she succeeded in presenting topic content, as well as ensuring "good" use of the relating component.

When planning her presentations and assignments, Martha allowed several opportunities to explicitly and consistently use the terminology of the relating component. And, because her students were already familiar with the scientific literacy framework, she knew that they would easily recognize the importance of the connections she made between it and topic content. To emphasize these connections, she included relating items on an old worksheet, designed a few additional assignments, and asked students direct questions about the connections during her recitations. An additional example of making good use of a scientific literacy relating component is in the Appendix. In the third guidebook in this series, we will provide a more detailed framework of how to develop and incorporate the scientific literacy framework into your curriculum.

WHY IS SCIENTIFIC LITERACY IMPORTANT?

Often, scientific literacy is talked about as if it were a self-evident goal for science instruction. However, we realize that simply stating that scientific literacy is a worthy goal is probably not enough to convince you and other teachers to incorporate the relating components of scientific literacy into your curriculum. For example, it may seem like a significant drawback that going beyond teaching content and making good use of scientific literacy is going to require some extra planning, time, and resources. Or, you may question whether incorporating the scientific literacy components will take time away from your students learning the "basic facts" of science.

While these (or others) are certainly valid concerns, we think that the benefits of making good use of scientific literacy overcome any of the initial difficulties with implementing the approach or achieving curriculum goals. These benefits are as follows:

1. <u>The scientific literacy framework helps students understand in what ways science content is meaningful.</u> Students sometimes have difficulty understanding why a subject matter is worth learning and why assignments are worth doing. This is particularly the case if they view the subject matter as a string of disassociated facts. The scientific literacy framework addresses this problem by providing students with a set of concepts that are likely to add meaning to topic content. In addition, the use of the relating components makes it more likely that they will see how science links to other academic subjects (e.g., history, mathematics) and to their own observations about their personal lives, current events, and society.

2. <u>The scientific literacy framework is an important learning tool for students.</u> It is known that in the natural learning process, both children and adults develop sets of different "mental schemes" based on their knowledge and experiences in the world. As people encounter new information throughout their lives, they place this information in existing schemes or else develop new schemes to accommodate it. Placing the information in schemes greatly increases the likelihood that the information will be retained in memory for a long period of time.

It thus appears that the process of formal schooling is often at odds with this natural process; students are often called upon to memorize information for which they have no existing schemes. By presenting your students with the scientific literacy framework, you are giving them a scheme that may help them "place" the topic content, increasing their ability to master and recall the material.

3. The scientific literacy framework helps to motivate students in science. Because the scientific literacy framework gives science topic content more meaning and provides a useful learning tool, one can anticipate that students' motivation to learn science also will increase. A motivated student is generally more responsive to what is presented in class and more willing to take efforts to learn topic content.

4. The relating components provide valuable and useful information. As we said at the outset, becoming scientifically literate involves a working knowledge of the history of science, its methods, and its relevance to society and personal use. With experience in relating content to these aspects of science, students are not only learning science content, but are also gaining the necessary knowledge and skills to make reasonable decisions about issues having social or personal impact. By providing your students with opportunities to explore the history of scientific thought, to gather valid scientific and technological information and to assess its influence on personal or social decisions, you are helping them prepare for their roles as "scientifically literate" adults.

5. The scientific literacy framework is an important thinking tool for you, the teacher. Scientific literacy is not just a goal for students. It also provides a conceptual framework within which you can make your instructional objectives and activities more meaningful. The scientific literacy framework gives you the opportunity to decide, for each topic, the major reasons why the topic content is worth teaching to students (i.e. where it fits in the broader scheme of human endeavors). Thus, the framework lays the basis for a coherent and rational presentation of the topic content.

SUMMARY

The purpose of this guidebook was to introduce you to a working definition of scientific literacy and to show why it is an important and beneficial goal for intermediate life science instruction. This guidebook also sought to provide some concrete examples of how to make good use of scientific literacy, including specific principles for making scientific literacy a regular part of your curriculum.

The second guidebook in this series, "How is Intermediate Science Taught?," describes recent findings about intermediate science instruction. Particular attention is given to how teachers spontaneously use scientific literacy in their presentations and assignments to students. The third guidebook, "How to Build Opportunities for Scientific Literacy into Your Curriculum" will provide you with the experience of planning the use of scientific literacy with one topic.

RECOMMENDED RESOURCES

Periodicals:

<u>Discover</u> (monthly; $2.00 - $2.50/copy) -- moderate level of advertising

<u>National Geographic</u>

<u>Omni</u> (monthly; $2.00 - $2.50/copy) -- high level of advertising; use of many photographs and illustrations

<u>Science 85</u> (10 issues per year; $1.40 - $2.00/copy) -- moderate level of advertising

<u>Science Digest</u> (monthly; $.70 - $2.00/copy) -- low level of adver·ising; a good value

Books:

Boorstein, D. J. (1983). <u>The Discoverers</u>. New York: Random House.

Goldstein, M., & Goldstein, I. (1984). <u>The experience of science: An interdisciplinary approach</u>. New York: Plenum.

WGBH Boston. (1983). <u>Nova: Adventures in Science</u>. Reading, MA: Addison-Wesley.

Television:

1-2-3 Contact, PBS

Healthnotes, PBS

Newton's Apple, PBS

Nova, PBS

20/20, ABC

Can you think of other popularly available resources that could help teachers build up a scientific literacy folder?

APPENDIX

ADDITIONAL EXAMPLE OF MAKING GOOD USE

Principle #

"Martha Curie" teaches intermediate life science. In the next several weeks, she will cover human systems, beginning with an overview of the skeletal and muscular systems. When Martha sits down to plan this topic, she notes that her text makes brief mention of the fact that shoes help to protect man's skeleton from damage caused by walking and running on hard surfaces, such as asphalt streets. Recalling a recent TV segment on the latest exercise equipment, she wonders how many other consumer products serve to protect man's musculoskeletal system. This leads Martha to consider the possibility of presenting topic content in terms of the consequences of technological information (i.e. relating content to the societal impact of science).

2 - build up a resource folder

4 - focus on no more than two

3 - plan before you begin topic

When she turns to her scientific literacy folder and a few popular magazines, Martha discovers that in addition to products such as running shoes, there have been several recent advances in the fields of biomechanics and sports medicine that can give context to knowledge about the musculoskeletal system. She decides that this theme -- relating content to the societal impact of science -- is an excellent organizer for this topic. After some consideration, Martha outlines the following plan for herself:

- Introduce the topic by having students describe what happens when a football quarterback throws a ball to a player downfield. Have students identify the various parts of the body that are involved and what movements typically take place.

- Introduce biomechanics as the field which systematically studies human movement. Explain that sophisticated knowledge of the structure of the human skeleton and how muscles control movement has helped athletes move efficiently and place less strain on their skeleton.

Principle #

• Use student descriptions of the quarterback as starting points for discussing the skeletal system. Introduce the names of major bones and the structure and function of ball and socket, hinge and partially moveable joints. Compare bone with cartilage and give examples of the parts of body containing each. Outline the major functions of the skeletal system (protection, support framework, aids movement, manufactures blood cells).

• Return to the football example, asking students to think about the stresses and strains placed on the skeleton during this physical activity. Note that with each running step, pressure three times the body weight is placed on each foot. Have students suggest ways that football players (or other athletes) protect the skeleton (e.g., running shoes, shoulder and knee pads, helmets, etc.). Note that some developments designed to help athletics are actually detrimental to athletes (e.g., astroturf was designed to provide an easy-to-care-for, evenly-surfaced playing field, but is actually much harder, and thus more stressful, on the skeleton).

• Introduce the muscular system by outlining major muscle names and explaining the function of the three major muscle types (voluntary, involuntary, and cardiac).

• Describe the principles behind contraction and how muscles combine with the skeleton to allow movement. Explain how muscles obtain the energy needed for their operation.

• Return to the field of biomechanics and present several recent technological innovations utilized by Olympic and professional athletes to monitor and improve muscular performance.

(a) Computers that are capable of analyzing video-taped pictures of an athlete's activities and suggesting ways to alter movements for maximum performance.

(b) Diagonistic techniques that measure an athlete's natural capabilities (e.g., resiliance and flexibility of joints, muscle strength) and channel individuals into the sports for which they are best suited.

Principle #

(c) Biofeedback methods that make athletes more aware of the complex movements involved in an activity. Feedback allows athletes to control muscles and alter behaviors that were previously not under voluntary control.

• Review major muscle types and joints, asking students to identify which muscle groups, bones, and joints are most likely to be studied by biomechanics.

6 - be consistent with relating component

With this outline sketched out, Martha goes on to think about the kinds of activities she can use to convey the above information and engage students in the topic. Martha decides to present the information in recitations spaced evenly throughout the week.

5 - be explicit with relating component

1 - introduce students to framework at beginning of year

At the first recitation, she tells students directly that she will be presenting information about the skeletal and muscular systems in terms of the societal impact of science. She refers back to the scientific literacy framework she presented at the beginning of the year.

7 - reinforce students' understanding by referring to components during in-class questions

During all her recitations, Martha makes a point to ask students questions to get them involved in the recitations. These questions tap students' comprehension of the various terms and concepts she introduced as well as their knowledge of how the field of biomechanics has influenced what we know about human movement.

7 - reinforce students' understanding by referring to components on assignments

In terms of assignments, Martha uses several for the topic. First, she uses a worksheet adopted from the text which asks students to map the muscles and bones involved in various activities (e.g., running, playing tennis, throwing a ball). She adds a couple of questions to the worksheet that tap students' understanding of the relating material (e.g., explain how biofeedback is used to help athletes improve performance). She also assigns a new worksheet which asks students to pick an injury to the skeletal or muscular system associated with exercise, identify which muscles, bones or cartilage are involved, and suggest how new products or technology can be used to protect the athlete from injury. On the

Principle #

final, Martha asks students to describe the structure of the skeletal and muscular systems, and includes questions which tap their understanding of the principles underlying muscule movement and the importance of the skeletal system to man's survival. In addition, she asks students to discuss the societal impact of technological advances such as biofeedback or computer modeling (e.g. should Olympic athletes be allowed to utilize such tecnology? Or only professional athletes? How would you feel about this if you were from a small country that did not have access to this level of technology?). Lastly, Martha describes the symptoms of a hypothetical musculoskeletal injury and asks students to describe how they would use technology to prevent other atheltes from contracting the same injury.

TRAINING NOTES

The preceding materials are designed for an inservice workshop to be conducted with intermediate life science teachers. They provide an overview of the framework of scientific literacy and encourage teachers to think about how the scientific literacy components can be an effective tool for their teaching and curriculum planning. The main goal of this workshop should be to give teachers a good working definition of scientific literacy and some sense of how scientific literacy actually can be applied in class. (The third guidebook in this series will give teachers more experience in developing their own applications of scientific literacy.) The workshop can be held during or after school. A minimum of two hours will be required to cover the basic materials. The materials also lend themselves to longer discussion during an entire inservice day or over the course of several shorter inservice workshops. When more time is available, the trainer has the opportunity to work individually with teachers in recognizing potential links between their science curriculum and the scientific literacy components.

However these materials are used, it must be remembered that they present ideas that may be new to many teachers and that imply a change in typical intermediate life science instruction. The role of the trainer is to facilitate discussion that demystifies the scientific literacy components and provides concrete examples of the use of these components in regular science lessons. In so doing, the trainer must maintain a balance between uncritically accepting the ideas of the participants and appearing pedantic. Often this balance can be set by: 1) Listening <u>carefully</u> to the confusions of the participants and allowing them to express fully their own ideas -- no matter how erroneous; 2) Responding to these confusions in a matter of fact way that focuses on participants' incorrect ideas rather than the participants (e.g., "I don't think that's what the packet means here" rather than "I think you are confused."); and 3) Allowing participants to reject the ideas expressed in the packet, should they wish.

We believe this workshop can be conducted most successfully with teachers who teach the same science courses (e.g., 8th grade life science; 7th grade general science) and who use the same science textbook. The trainer should be familiar with the curriculum of the courses taught by the teachers attending the workshop and the content of the textbook they use.

Try to establish a warm, relaxed atmosphere so that teachers will feel comfortable discussing new ideas. If possible, seat the participants in such a way that they are able to see each other. Begin the workshop by giving the participants an opportunity to introduce themselves and say something about their teaching. You might want to ask the participants to tell the group what the words scientific literacy mean to them, or ask them what they like most about teaching science. Then present a brief overview of what will be discussed today. Use the following three overheads to present a visual image of the scientific literacy components and emphasize main points. Do not expect that teachers will have read the materials before coming to the workshop. Structure your own presentation so that teachers have a chance to read the booklet, discuss as a group the questions that are posed in boxes, and then hear your own summation and discussion of the ideas. Ask the participants in they have questions frequently in order to clear up misunderstandings as they develop.

At the end of the workshop ask teachers to complete the workshop evaluation form. Also complete one of the forms yourself so you can check your own impressions against those of the participants.

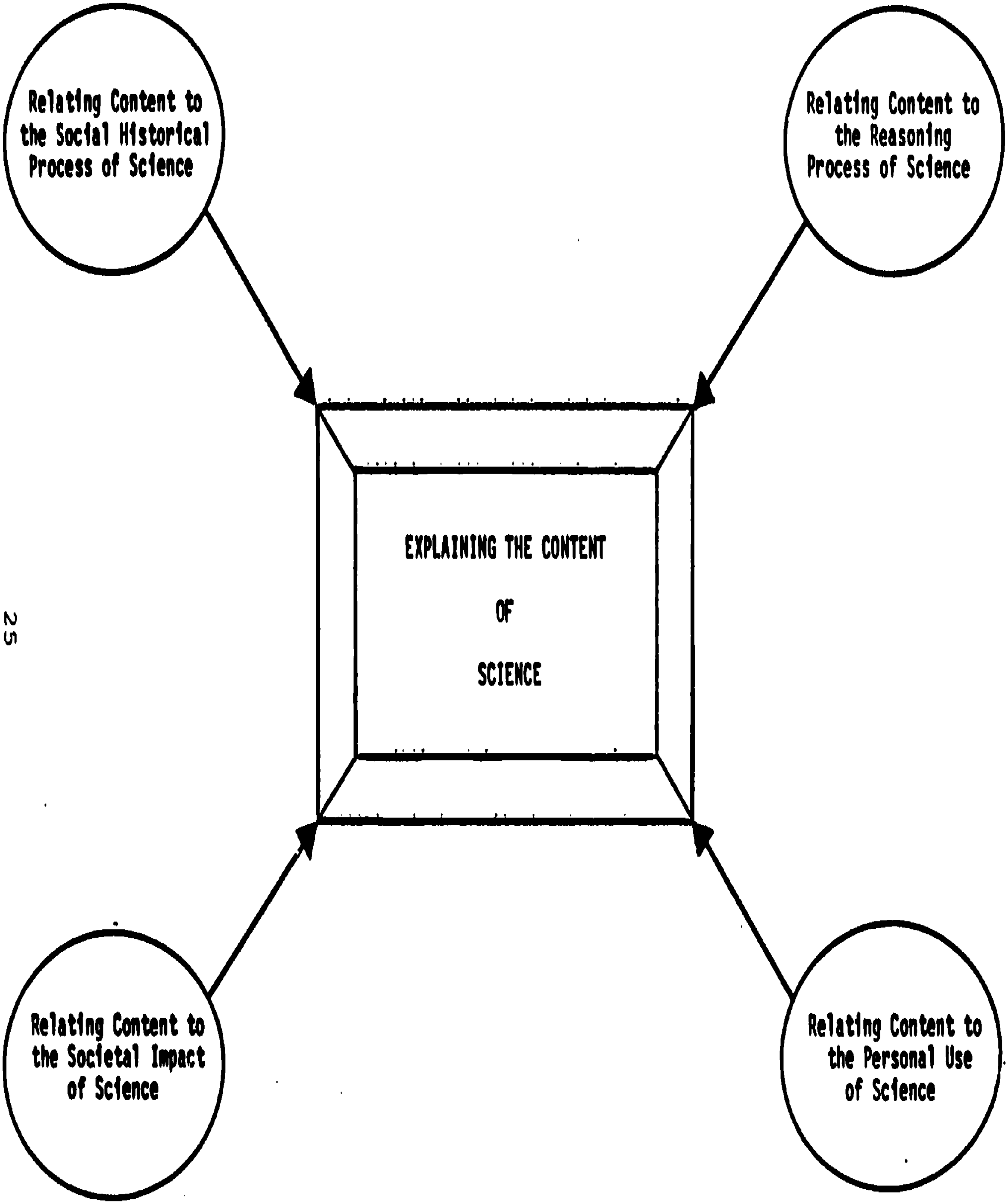

Figure 1. The Scientific Literacy Framework

PRINCIPLES FOR USING SCIENTIFIC LITERACY

1. INTRODUCE YOUR STUDENTS TO THE SCIENTIFIC FRAMEWORK AT THE BEGINNING OF THE SCHOOL YEAR.

2. BUILD UP YOUR OWN SCIENTIFIC LITERACY RESOURCE FOLDER.

3. BEFORE YOU BEGIN EACH TOPIC, SIT DOWN AND PLAN WHAT PARTS OF THE SCIENTIFIC LITERACY FRAMEWORK YOU WILL USE AND HOW YOU WILL USE THEM.

4. FOR EACH TOPIC, FOCUS ON EXPLAINING CONTENT IN THE CONTEXT OF NO MORE THAN TWO OF THE RELATING COMPONENTS.

5. WHEN YOU USE A RELATING COMPONENT, BE EXPLICIT.

6. WHEN YOU USE A RELATING COMPONENT, BE CONSISTENT.

7. WHEN YOU REFER TO THE SCIENTIFIC LITERACY COMPONENTS IN YOUR PRESENTATIONS, REINFORCE STUDENTS' UNDERSTANDING BY ASKING THEM QUESTIONS ABOUT THE SAME COMPONENTS IN CLASS AND ON THEIR ASSIGNMENTS.

WHY IS SCIENTIFIC LITERACY IMPORTANT?

1. THE SCIENTIFIC LITERACY FRAMEWORK HELPS STUDENTS UNDERSTAND IN WHAT WAYS SCIENCE CONTENT IS MEANINGFUL.

2. THE SCIENTIFIC LITERACY FRAMEWORK IS AN IMPORTANT LEARNING TOOL FOR STUDENTS.

3. THE SCIENTIFIC LITERACY FRAMEWORK HELPS TO MOTIVATE STUDENTS IN SCIENCE.

4. THE RELATING COMPONENTS PROVIDE VALUABLE AND USEFUL INFORMATION.

5. THE SCIENTIFIC LITERACY FRAMEWORK IS AN IMPORTANT THINKING TOOL FOR THE TEACHER.