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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 second of a three part series of guidebooks describes recent findings about intermediate science instruction with particular attention given to how teachers spontaneously use scientific literacy in their classes. Descriptions are drawn largely from the International Life Science Study (ILSS) which was conducted in 11 seventh grade life science classes. Observations and findings are reported about: (1) how time was used for different class activities (indicating the average percent of time devoted to major class activities); (2) how time was used for scientific literacy (examining how the five components of scientific literacy were used in the class activities of recitation and seatwork); (3) the way in which teachers use scientific literacy (presenting an example of how a teacher talked about the social historical context and societal impact of science); and (4) implications for increasing teachers' use of scientific literacy (discussing factors that may contribute to teachers' generally low use of scientific literacy). An appendix contains training notes and materials for overhead reproduction. (ML)

Secondary Science and Mathematics Improvement Program

HOW IS INTERMEDIATE LIFE SCIENCE TAUGHT?

A Guidebook for Teachers of Life Science at the Intermediate Level

Intermediate Life Science Study Series, Volume II

Far West Laboratory for Educational Research and Development

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PREFACE

This guidebook is the second 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 its companions represent an effort to translate the background and findings of the Intermediate Life Science Study into a set of materials that provides teachers with new knowledge about the goals of science instruction and its current practice as well as 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. John Taylor, Teaching and Learning Division, National Institute of Education, for his support in this and other work. The Institute's interest in exploring innovative ways of approaching the problems that confront educators and its encouragement of educational excellence are appreciated.

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SOURCES OF INFORMATION ABOUT INTERMEDIATE LIFE SCIENCE INSTRUCTION

Background

The previous guidebook introduced <u>scientific literacy</u> as an important goal for intermediate life science instruction. In this guidebook, we turn to examine what we know about current practices in intermediate life science instruction and the extent to which the goal of scientific literacy is reached. This examination can serve three purposes. First, an up-to-date description of current practices can be useful because it gives you a sense of what "typical" science instruction is. Of course, one should not assume that because instruction is "typical," it is also the most desirable. A judgment of good instruction depends on the criteria that are applied, and, thus, it is not always easy to know what the strengths and weaknesses of "typical" instruction are. Second, this sense of the "typical" will allow you to compare your instruction with that of other teachers you know. A third purpose of this description of current practices is to allow you to assess the extent to which "typical" instruction and your instruction addresses the goal of scientific literacy. Recognizing the distance between current practices and this goal helps in setting a realistic course towards improved use of scientific literacy.

Only a few sources of information are available about current practices in intermediate life science instruction, but these are adequate to give us some certainty about what generally occurs in classrooms. One reason for the scarcity of information is that much past research in science instruction has focused solely on comparing the benefits of different curriculum materials. This research does not usually depict "typical" classroom instruction. Also, the intermediate level has typically been overlooked in educational research in general. Only very recently, then, has there been research on the broader spectrum of activities that characterize science instruction, some of which has focused at the intermediate level.

In this guidebook, we will draw largely from the Intermediate Life Science Study (ILSS) conducted at the Far West Laboratory. The methods of this study are summarized below. A few other studies conducted in the United States and Canada also have produced findings very similar to those from the ILSS, and some of these will be mentioned.

Methods for the Intermediate Life Science Study (ILSS)

The ILSS was conducted in eleven seventh grade life science classes. The classes were located in both California and Utah. In terms of background, all but two of the teachers had some specialization in science. In addition, their general teaching experience was substantial, averaging at 13 years. Initial class sizes ranged from 24 to 32 students, with an average of 29.

Each class was observed during the teaching of two different life science topics. Some of the topics frequently observed included Protists, Genetics, Human Systems, and Ecology. Observations of the two topics took place in the winter and spring of the 1983-1984 school year. The length of time spent on a topic ranged from 4 to 12 days, with an average of 8.

In the next sections, we will focus on several kinds of information from the ILSS, based largely on observers' notes. We will describe how time was used in the eleven life science classes, looking first at different kinds of activities and then at the use of scientific literacy. The way in which scientific literacy was used will be reviewed next. Finally, we will discuss the implications of all these findings in meeting the goal of scientific literacy.

HOW IS TIME USED FOR DIFFERENT CLASS ACTIVITIES?

Information from the Intermediate Life Science Study indicates that class time is typically allocated to five major activities. Table 1 shows that the average teacher in the study spent 32% of the time leading recitations. Teacher recitation refers to time when the teacher is presenting information to the entire class, including any question-and-answer sessions when the teacher is the primary initiator of questions. The average teacher spent the next largest segment of time--approximately 21%--having students do seatwork. Seatwork refers to time when students work alone reading silently, completing worksheets, or taking exams. During this time the teacher may communicate with individual students, but rarely with the class as a whole. Together then, recitation and seatwork usually account for more than half of all time spent in intermediate life science classes.

As Table 1 shows, two of the remaining three activities are non-academic in nature. For the first, transitions, interruptions, and waste time, the average teacher spent approximately 17% of class time. This refers to time for management of class and school affairs not related to an academic purpose (e.g., taking roll, switching from one activity to another). It also includes time that has no clear academic or management purpose (e.g., students socializing with one another). For the second, procedures, the average teacher spent approximately 11% of class time. Procedures entails things like passing out supplies, teacher directions, and collecting materials--in other words, steps that support academic work but do not directly lead to learning.

The fifth major activity is laboratory exercises. The average teacher spent approximately 10% of class time on this activity. Laboratory exercises are unique to science classes, referring to time devoted to the scientific processes of observation, measurement, and data recording.

Table 1 shows that the average teacher spent little or no class time on four other activities. Surrogate instruction--instruction through film, video-tape, guest speaker, etc.--occurred approximately 4% of the time. The average teacher spent 3% of the time on non-academic instruction--that is, formal instruction about non-life science topics. The average teacher used demonstration about 2% of the time. Demonstration occurs when the teacher manipulates science materials or equipment to illustrate a concept or procedure that students will use. Last, group discussion, was not observed at all in any of the classes. Group discussion refers to discussion and question-and-answer among students, where the exchange is facilitated by the teacher but students have primary control.

Table 1

Average Percent of Time Devoted to Different Class Activities

	Average Percent of Time	Class Ranges*
<u>Recitation</u>	33	(16-48)
<u>Seatwork</u>	21	(0-44)
Transitions, Interruptions, Waste Time	17	(9-31)
Procedures	11	(6-15)
<u>Laboratory Exercises</u>	10	(.6-17)
<u>Surrogate Instruction</u>	4	(0-7)
Nonacademic Instruction	3	(1-5)
<u>Demonstration</u>	2	(0-7)
<u>Group Discussion</u>	0	---

*Class ranges indicate the highest and lowest percent of time recorded among the eleven teachers in the ILSS Study.

Note: Academic activities are underlined.

What is your reaction to the typical time use pattern for different class activities?

In sum, the great majority of time in intermediate life science classes is typically allocated to five kinds of activities. In order of frequency, they are: 1) recitation, 2) seatwork, 3) transitions, interruptions, and waste time, 4) procedures, and 5) laboratory exercises. While this is typical, not all teachers followed this pattern closely. Indeed, the ranges in Table 1 indicate that some teachers used particular activities considerably more or less than the "average" teacher. Nonetheless, the average time use pattern from the ILSS is quite similar to the average time use patterns from other studies. In John Goodlad's Study of Schooling, for example, junior high level science classes involved 24% recitation, 20% seatwork, 16% laboratory exercises, and 8% surrogate instruction. A study of high school science classes done at Far West Laboratory also yielded similar time use patterns.

HOW IS TIME USED FOR SCIENTIFIC LITERACY?

As indicated in the first guidebook, the scientific literacy framework has 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.

Below, we examine how the five components are used during class time devoted to recitation and seatwork, respectively. We are focusing on recitation and seatwork not only because they are the two most common activities, but also because they are activities that usually involve every student in the class. Recall that scientific literacy is an important goal for all students as members of society, not just those who are headed toward careers in the science professions.

Recitation Time

Information from the Intermediate Life Science Study (ILSS) indicates that teachers typically devote the great majority of their recitation time to explaining the content of science--the first component of the scientific literacy framework.

Table 2 shows you the percentage of recitation time that the eleven teachers in the ILSS devoted to explaining the content of science and the other four relating components. As you can see, with the exception of Teacher 1, all teachers devoted only a small portion of their recitation time--less than 5%--to making connections between science content and any of the four relating components. Five of the teachers devoted less than 1% of their recitation time to this purpose. The average total percentage of recitation time devoted to all four relating components was 2.7%. While it seems sensible that explaining content should be the main purpose of teacher recitation, it is surprising that it takes up nearly all recitation time.

Table 2

Percent of Recitation Time Devoted to the Five Scientific Literacy Components, by Teacher

Teacher	% Recitation Time Devoted to Explaining Content	% Recitation Time Devoted to Four Relating Components
1	89.0	11.0
2	100.0	0.0
3	99.8	0.2
4	96.2	3.8
5	96.0	4.0
6	99.3	0.7
7	99.5	0.5
8	99.5	0.5
9	96.0	4.0
10	98.8	1.2
11	96.5	3.5
Average	97.3	2.7

How do these results compare with your expectations for how much scientific literacy is typically used? Do you think that devoting this percentage of time to the relating components is enough?

It is difficult to speak with confidence about the frequency with which any individual relating component was used because all four relating components received so little attention. There is some indication that relating content to the reasoning process of science was the most-used relating component during the first topic, but it was virtually neglected during the second topic; in its place, relating content to the societal impact of science was most-used during the second topic. This relating component received the least mention during the first topic. This possible shift in the emphasis of particular relating components may be due to the fact that some topics are more amenable to particular relating components than others and are taught at different times in the school year.

Case studies of science classes done in the United States and Canada support the ILSS findings that while most teachers do make use of the relating components of scientific literacy, they do so to a very small degree. In these studies, teachers often mentioned time pressure as a major factor preventing them from addressing the relating components.

Seatwork Time

Seatwork assignments provide very concrete indications to students about what is important and valued in a given course. In the ILSS, the assignments given during seatwork were examined in terms of the extent to which they reflected the five different components of scientific literacy. A total of 64 worksheets and 31 exams were collected in the eleven classes during both topic observation periods. Table 3 presents information on the percentage of worksheet and exam items that reflected either science content or any of the four relating components. This information is shown for each teacher and each topic observation period.

Table 3 indicates that in most instances, teachers assigned worksheets and exams where 100% of the items tapped science content only. Of the 9 teachers who assigned worksheets during the first topic, 2 included items that linked topic content to one or more of the relating components. These teachers had a total of ten relating items on their worksheets, comprising approximately 2% of the worksheet items assigned during Topic 1. These focused on the social historical process of science (e.g., "What did Louis Pasteur do?" and "Why was the microscope

Table 3

Percentage of Task Items Devoted to Science Content and to Relating Components of Scientific Literacy on Worksheets and Exams

	Topic 1				Topic 2			
Teacher	Worksheets		Exams		Worksheets		Exams	
	Content	Relating	Content	Relating	Content	Relating	Content	Relating
1	100.0		100.0		75.2	24.8 (2,3,4)	96.7	6.5 (3,4)
2	94.8	5.2 (1,3)[a]	100.0		100.0		100.0	
3	100.0		100.0		90.0	10.0 (4)	83.3	16.6 (4)
4	100.0		90.5	9.5 (2,3)	72.7	27.3 (2)	87.0	13.0 (2)
5	100.0		100.0		100.0		93.3	6.7 (1)
6	100.0		100.0		N O N E		N O N E	
7	N O N E		100.0		100.0		100.0	
8	100.0		100.0		N O N E		100.0	
9	N O N E		85.0	15.0 (1,2)	90.0	10.0 (2,4)	100.0	
10	98.0	2.0 (1)	98.0	2.0 (1)	100.0		100.0	
11	100.0		100.0		93.8	6.1 (3)	81.0	19.0 (3)

[a]Numbers in parentheses refer to the following components of Scientific Literacy: 1) History of Science; 2) Science as a Reasoning Process; 3) Science and Society/Technology; and 4) Positive Attitudes toward Science.

important in the discovery of the kingdom of protists?") and the societal impact of science (e.g., "How is bacteria useful to man?"). Relating items appeared slightly less frequently on the exams assigned during the first topic than on the worksheets (8 items). For the second topic, the use of relating items increased in both worksheets and exams, accounting for approximately one-fifteenth (7%) of the items that were assigned (although there were 4 teachers who used science content items only). During the second topic, all the relating components were represented.

The relating items on worksheets and exams also were examined to see if they usually were associated with a teacher's use of the relating components during recitations. Here, the results appeared mixed. There were a few teachers who clearly included relating items on worksheets and exams as a means of reinforcing a relating concept they first introduced during a recitation. On the other hand, there were some teachers who had relating items on their worksheets and exams, where the relating concepts had not been introduced during a recitation. In some of these instances, the relating items referred to concepts introduced by a textbook or film, but never mentioned by the teacher in class.

In sum, approximately half of the ILSS teachers included a small percentage of worksheet or exam items which pertained to the relating components of scientific literacy. Furthermore, use of these items seemed to increase over the course of the year. In some cases, these items reflected concepts the teacher had introduced to the class. As with the recitation results, these seatwork results indicate that teachers make some use of the relating components of scientific literacy on their own. However, it appears that incorporating scientific literacy into assignments may be more difficult than addressing them during recitations, at least for some teachers.

How do these results compare with your expectations of how frequently scientific literacy is incorporated into seatwork activities? What might account for differences in the use of the relating components in seatwork versus recitations?

THE WAY IN WHICH TEACHERS USE SCIENTIFIC LITERACY

We already have described the amount of recitation time teachers devoted to the relating components of scientific literacy. Clearly, the way in which teachers talked about the relating components during recitations is also important. Were their references clear and accurate? Did their references have continuity and logic within the entire lesson? To address these questions, we examined observers' records of those recitation segments when teachers addressed the relating components. These notes were based on audiotapes of the class lessons. Here is an example of the way one teacher talked about the social historical context and societal impact of science.

> TEACHER: There was a man by the name of George, no Gregory Mendel. He was an Austrian monk. And he found all of these traits out by working with peas, common ordinary peas, like you plant in your garden. See back there in the back, I've got my tomatoes and my cucumbers and my peppers growing. When your father or your mother or whoever plants their garden, they're going to look for the best variety. And a lot of them will go and buy hybrids, and that's a cross-breed between plants . . . (goes on to other content for 20 minutes) . . . So, we'll get into a little bit, but I don't want to get into it too deeply because, see, we're touching on genetics, which is covered in your 9th grade biology class . . . There are a lot of geneticists in the world that make a good amount of money, by working with different crosses, with animals, getting hybrids of plants that grow better for an area than some plants do. If you get a chance, next time you're at the store, you look, -- like tomatoes, peppers, cucumbers. Now, I'm not sure if I've still got my packages over here. Okay, here's an example . . . This is a tomato which is a hybrid tomato, which means it's been crossed with other tomatoes and they come up with this particular tomato and they call it a hybrid and it's called a beefsteak tomato.

What do you think are the strengths and weaknesses of this particular example?

First, this teacher can be complemented for alluding to the social historical context and societal impact of the science content his class is studying. By doing so, the teacher clearly is trying to make the topic of genetics "come alive" and be relevant to students. On the other hand, we should note that the teacher does not mention how important Mendel was in the overall development of genetics or describe the main purpose of his research. In addition, the teacher uses scientific terms like "hybrid" and "traits" without providing any explanations of their meaning. What the teacher did say seems "off the cuff" and not that well connected. Thus, while we might expect that students would gain an awareness of a historical figure behind genetics and practical applications for genetics, they might not gain a good understanding of the importance of Mendel and the purpose and methods of cross-breeding from this lecture.

The example here is in many ways typical of the way we saw teachers use the relating components. In general, they made some interesting, spontaneous references to the relating components. Such an approach, however, limits the use of the relating components as unifying themes, carried through different lessons on a topic. Also, it becomes difficult to really clarify for students what many of the relating ideas mean or to plan assignments based on the relating ideas. This contrasts with an approach where teachers plan what relating component(s) to focus on and what they want to say ahead of time, including how their assignments can reinforce their presentations.

IMPLICATIONS FOR INCREASING TEACHERS' USE OF SCIENTIFIC LITERACY

In the first guidebook, we emphasized that making good use of scientific literacy was important because it can increase students' learning and motivation in science. The results in this guidebook suggest that while the typical teacher of intermediate life science instruction makes some use of the relating components of scientific literacy, he or she does not use these components to full advantage in his or her instruction. Thus, there is a gap between typical practice and the good use of scientific literacy that science educators talk about.

The research reviewed here does not give us much information about why the gap between practice and scientific literacy goals exists. No doubt several factors are at work. For one, teachers in all these studies never received any training about using scientific literacy as a framework for teaching. Second, review of current textbooks and other supplementary materials indicates that they do not reflect a science framework and do little to introduce and reinforce anything other than science content. Third, some research indicates that while most science teachers have vague notions about what scientific literacy means, these notions are not sufficiently developed to provide clear guidelines for teaching. Again, this is probably because most teachers have never participated in professional development activities where scientific literacy is defined and discussed. Fourth, there may be little recognition of scientific literacy as a goal for instruction at the school or district level. Only now are certain states beginning to draw up guidelines for addressing scientific literacy. All of these reasons, then, help explain the low use of scientific literacy in typical instruction today.

> In your own experience, what are some other factors that may contribute to teachers' generally low use of scientific literacy?

What does the gap between typical science teaching and the goal of scientific literacy mean for teachers' efforts to use scientific literacy? For one, we hope it suggests why guidebooks and teacher training are important sources of support to get teachers started in thinking about and using scientific literacy. Second, the gap suggests that a realistic course for teachers entails setting a series of small sub-goals. Clearly, it is unreasonable for a teacher to quickly reshape his or her entire curriculum around the scientific literacy framework. Instead, one's first goals might include: 1) thoroughly familiarizing oneself with the scientific literacy framework, and 2) planning one topic at a time according to the scientific literacy framework. Because this planning takes valuable time and resources, it may only be possible to plan a few topics during a school year.

In the next guidebook in this series, you will have the opportunity to plan a topic using the scientific literacy framework. This guidebook is entitled, "How to Build Opportunities for Scientific Literacy Into Your Curriculum."

APPENDIX

TRAINING NOTES

The preceding materials are designed for an inservice workshop to be conducted with intermediate life science teachers. They provide an overview of current practices in intermediate life science education in relation to scientific literacy and encourage teachers to evaluate how the relating components are typically used. The main goal of this workshop should be to further acquaint teachers with the scientific literacy framework and give them some sense of how scientific literacy is applied in recitations and seatwork. (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 about the methods, results and implications of the presented research and encourage teachers to be open with their interpretations and reactions. 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 carefully to the confusions of the participants, 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 on the participants themselves (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 thoughts they have had about scientific literacy since the first workshop. Then present a brief overview of what will be discussed today. Use the following three overheads to present a visual image of the results of the study 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.

Table 1

Average Percent of Time Devoted to Different Class Ac /ities

	Average Percent of Time	Class Ranges*
Recitation	33	(16-48)
Seatwork	21	(0-44)
Transitions, Interruptions, Waste Time	17	(9-31)
Procedures	11	(6-15)
Laboratory Exercises	10	(.6-17)
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*Class ranges indicate the highest and lowest percent of time recorded among the eleven teachers in the ILSS Study.

Note: Academic activities are underlined.

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3	100.0		100.0		90.0	10.0 (4)	83.3	16.6 (4)
4	100.0		90.5	9.5 (2,3)	72.7	27.3 (2)	87.0	13.0 (2)
5	100.0		100.0		100.0		93.3	6.7 (1)
6	100.0		100.0		N O N E		N O N E	
7	N O N E		100.0		100.0		100.0	
8	100.0		100.0		N O N E		100.0	
9	N O N E		85.0	15.0 (1,2)	90.0	10.0 (2,4)	100.0	
10	98.0	2.0 (1)	98.0	2.0 (1)	100.0		100.0	
11	100.0		100.0		93.8	6.1 (3)	81.0	19.0 (3)

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