LEARNING TO TEACH SCIENCE WITH WRITING

IMPLEMENTATION OF THE SEATTLE ELEMENTARY EXPOSITORY WRITING AND SCIENCE NOTEBOOKS PROGRAM IN TYPICAL CLASSROOMS

Laura Stokes
Heather Mitchell
Katherine Ramage

With assistance from
Mark St. John
Allison Murray
KC Choi (CRESST Center UCLA)

INVERNESS RESEARCH ASSOCIATES
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EXECUTIVE SUMMARY

I. INTRODUCTION

The Seattle Elementary Expository Writing and Science Notebooks Program

Between 1996 and 2003, the Seattle Public Schools (SPS) established a hands-on, inquiry-based K-5 science program. With support from the Stuart Foundation beginning in 1999, the district created the Expository Writing and Science Notebooks Program (we refer to it as Science Writing for brevity's sake) as an enhancement to the foundational science program. The Science Writing program aims to develop students' conceptual understanding in science, their scientific thinking, and their expository writing skills through a structured approach to using science notebooks. The Science Writing program has created a curriculum strand in writing for each adopted science unit and also offers after-school workshops for interested teachers. The program also supports a cadre of Lead Science Writing Teachers (LSWTs) who meet regularly to help refine program materials.

This research study

This study is the third that we at Inverness Research Associates have conducted of the Science Writing program[1]. Previous studies have focused on the benefits to students when the program is fully implemented in the classrooms of LSWTs. The current study, in contrast, focuses on implementation by "typical" science teachers, i.e., those who have participated in 4.5 - 7.5 hours of professional development (2-4 workshops) over the past three years. We asked:

1. What does implementation look like in the classrooms of teachers who have participated in an average number of science writing classes?
2. What factors influence and shape implementation in these typical classrooms?
3. What are the benefits to students of different degrees of implementation?

We also asked what we have come to call the "apple or pork chop" question; it is based on an analogy that probably held up better a hundred years ago but still expresses an important concern about benefits and costs of partial *vs*. full implementation of a highly specified program: A "half-baked apple" is not as good as a perfectly baked apple but is better than no apple at all and it does no harm. In contrast, a "half-baked pork chop" may do some harm, and so the costs may outweigh the benefits. Thus, given the challenges inherent in large-scale implementation of a teaching model, especially with a very modest amount of support, we wondered:

4. If there is implementation that is not full and faithful to the program design, does such implementation provide some benefits to student learning? To what extent, if any, are there detrimental effects from partial implementation?

Eighteen teachers in grades 1, 3, and 5 participated in the study; from their classrooms, we sampled 150 notebooks.[2] The study involved interviews with the teachers, as well as analysis of the student work in samples of 8-10 science notebooks per classroom. Lead Science Writing

[1] Reports are available from www.inverness-research.org.

[2] Nineteen teachers agreed to the study, and we originally planned to review 162 notebooks. For various reasons, eighteen teachers and 150 notebooks were actually involved throughout.

Teachers assessed the extent to which class samples of notebooks reflected full program implementation, and the LSWTs also rated the degree of individual student development in three areas: conceptual understanding, scientific thinking, and expository writing. A panel of twelve independent experts in science education and in writing assessed the extent to which the student work in notebooks reflected student learning goals that are important to the broader improvement community.

II. FINDINGS

Level of implementation. Of the 18 teachers in the sample, 8 were implementing the Science Writing program at a quite strong level. In 2 of these 8 instances the level of implementation was comparable to that expected of a Lead Science Writing Teacher. Of the other 10 teachers, 7 were implementing the program partially but inconsistently, and in 3 cases, there was little or no evidence of implementation, nor of any other consistent approach to science notebook use.

Factors influencing implementation. The degree of implementation of the Science Writing program appears to stem primarily from teachers' personal commitment to teach science (nearly always in the face of competing priorities in their schools), combined with the availability of high quality curriculum and professional development in science and in writing in science provided by the district. The teachers in our sample were not confident about their ability to teach science and so relied upon the district's science program to give them the means to actualize their personal commitment to teaching science. With the exception of 2 teachers whose schools place high priority on science or writing, these teachers feel they are stealing time from other subjects (math and reading first, sometimes social studies) when they teach science, and especially when they integrate full use of the Science Writing program's approaches to science notebooks into their teaching. Teachers with still-emergent confidence in science were less likely to persist toward full implementation of the Science Writing program in the face of time pressure caused by competing workplace priorities.

The majority of teachers told us they would accept additional professional development beyond the foundation of the writing classes, but would want it to be more closely linked to their individual teaching circumstances. Several also said they would be encouraged to devote more time to science and the full use of notebooks if others in their school were also teaching science this way and talking about it together.

Benefits to students. Individual student notebooks within the 8 class sets where implementation was quite strong revealed a wide range of student development in the three areas important to the program (conceptual understanding, scientific thinking, and expository writing), with most students' work showing a clear, positive trajectory of development. These notebooks were very similar to those of students in the classrooms of Lead Science Writing Teachers. Independent experts in science education and in writing found evidence in many of the notebooks that students had opportunities to use science notebooks in ways that real scientists do, and to use them as a valuable context for learning more science and also for learning to communicate in writing about science. The outside experts also noted that in some notebooks, students' writing was over-structured, leaving too little opportunity for independent thinking and the kind of grappling with meaning-making that scientists do through writing. The LSWTs, also, noted that in notebooks from classrooms where implementation was evident but not truly full, student work could tend to be overly mechanical. The strongest theme across both groups, however, was that the more that students were afforded opportunities to use their science notebooks systematically, the greater the contribution to their learning of both science and writing.

Benefits *vs.* detriments of partial implementation. Some of the Lead Science Writing teachers were concerned that future teachers would have to "un-teach" habits of notebook use developed in the classrooms where implementation of the Science Writing program was most minimal. However, the majority of LSWTs and all of the outside experts said that even minimal implementation of the program's approaches was better than no use of them at all. (In other words, the program seems to be an apple, not a pork chop.) The great majority of reviewers took a "glass half full" stance, stating their confidence that teachers would be able to improve their use of the notebooks and achieve full implementation if they kept at it.

III. REFLECTIONS AND IMPLICATIONS

Elementary school teachers must make choices within an environment that asks them to connect multiple curricula with learners with diverse and individual needs, to take into account local community values, to juggle multiple and changing policy directives, to suit all of this activity to the particular culture and demands of their school workplace, and to accomplish this within the constrained resource of time for instruction, individual professional development, and participation in school improvement. We take this reality of teaching into account as we reflect on what we learned and on implications for the program's development and its benefits to students and teachers.

Four ideas stand out from this study.

1. The model for teaching writing in science that the Expository Writing and Science Notebooks program espouses appears to be fundamentally sound in its ability to support student learning in both science and writing.

Findings from this study reinforce what we have learned from earlier studies about the value and benefits of this approach to using notebooks to support the teaching and learning of science and writing. Even when implemented at a minimal level, the great majority of reviewers believe there are clearly more benefits to students than detriments.

2. Given the realities of teaching elementary science, it is impressive that there is a degree of observable and productive implementation of the Expository Writing and Science Notebooks program by teachers who have taken a modest number of writing classes spread out over several years.

The conditions that favor high quality teaching of science in K-5 remain very weak compared to the conditions that inhibit the teaching of science with full and systematic use of notebooks for science and writing. Built upon the foundational science program, Seattle's Expository Writing and Science Notebooks program provides teachers with a model to follow (a supplemental curriculum and guidance as to teaching strategies) and enough workshop-style professional development to enable them to give it a try. Some teachers are able to implement the model well enough that students are benefiting in ways that are congruent with program goals.

3. Indications are that a greater proportion of committed teachers could achieve stronger implementation within the same context conditions if the Expository Writing and Science Notebooks program took two related steps in the future: To streamline the model, and to offer ongoing support for teachers as they work to master the teaching of science and this model for writing in science.

A good number of teachers in our sample attempted to follow the model but fell short of consistent implementation. This suggests that some teachers need greater capacity to implement productively in the face of inhibiting pressures. We suggest two steps the program can take, both derived out of our interviews with teachers and briefings with Lead Science Writing Teachers. They go hand-in-hand.

1. <u>Streamline the model and materials so they are more adaptable for less experienced teachers</u>. It is a maxim of curriculum implementation that a more complex model, with greater expectations for fidelity, can inhibit implementation that is both broad and full. As the Science Writing curriculum materials have been refined over the years, and then expanded to align with new state standards, the model has grown complex enough that teachers find it daunting. The several studies we have done suggest that it can be productively streamlined to encourage more effective initial implementation.

2. <u>Provide additional professional development support tied to specific teaching circumstances</u>. Everyone involved in this study—we researchers, the LSWTs, the outside experts, the 18 teachers—share the belief that *learning to teach hands-on science and to use this model for writing in science are developmental processes*. Taking some Science Writing classes and trying out the approaches is only the first step. The LSWTs have benefited greatly from co-planning the teaching of writing with specific science units as part of their field-testing role, and from discussing student work in notebooks together as part of our research. There are multiple ways to organize ongoing activities of these types, tailored to teachers' workplaces and teaching assignments.

4. We suspect that a broader degree of teacher commitment leading to wider implementation depends upon the extent to which science achieves higher priority at the school-site level. The higher school priority would bring science into sharper focus for individual teachers and make science a legitimate subject of teachers' joint work at their school sites.

Our sampling strategy for this study indicates that, for various reasons, about half the teachers who have taken 2-3 writing classes in the past three years are trying to implement the Science Writing program. We infer that at least some of these teachers' personal commitment to teaching science with writing was not strong enough to outweigh the low priority of science (and perhaps writing) in their schools and the time pressure against it. Stimulating schools to embrace science is a long-term effort but it seems necessary to broadening implementation substantially beyond the current level.

I. INTRODUCTION

Between 1996 and 2003, the Seattle Public Schools (SPS) worked to establish a hands-on, inquiry-based K-5 science program. They used the support of a Local System Change grant from NSF and worked in close partnership with scientist-educators in several science-rich institutions in Washington.[3] The science curriculum consists of three kit-based science units (STC, Insights, or FOSS) per year for each grade level. The district provides teachers with training in each science unit as well as optional additional professional development in relevant content.[4] With support from the Stuart Foundation, the Expository Writing and Science Notebooks Program (referred to from here on as the Science Writing program for brevity's sake) was built upon the solid foundation of the science program and is intended to serve as a major supplement to it.

This study is the third in a series that we at Inverness Research Associates have conducted of the Science Writing program, beginning in 2002 when the program was in its early stages. Previous studies have focused on the program as exemplified in the classrooms of Lead Science Writing Teachers, who receive regular ongoing professional development opportunities. The current study, in contrast, focuses on the Science Writing program as it is put into practice by teachers who have participated in a "typical" number of the program's workshops and have received no other formal support for implementing the program.

The Expository Writing and Science Notebooks Program

The Science Writing program has developed an explicit approach to enhancing the teaching of science through writing and to supporting the development of expository writing with science as the content. The approach is based on the rationale that "elementary students need structured support in three areas in order to write proficiently about science." The excerpt below is taken from an explanation of the approach and its rationale; I have underlined the "three areas" for clarification[5]:

> *First, students need to construct <u>understanding of science concepts</u> through engaging in guided and open inquiry. To help scaffold the inquiry, each lesson in a unit of study has a focus question, which is derived from the conceptual story of the unit and serves as a means of focusing the students' thinking as they engage in their investigations. These questions often, but not always, are the investigative question of an experiment (e.g.,*

[3] SPS Partners included the Department of Molecular Biotechnology at the University of Washington (UW) and later the Institute for Systems Biology (notably Leroy Hood and Valerie Logan), The Boeing Company, The Fred Hutchinson Cancer Research Center, and the Physics Education Group (PEG) in the Physics Department at the UW. Led by Dr. Hood, the stakeholders forged this partnership to support the implementation of an inquiry-based science program in all elementary schools.

[4] For an assessment of the capacities for science instruction that were built in the Seattle Public Schools through the LSC grant, see our report at http://www.inverness-research.org/reports/ab2002-05_Rpt_SeattleLSC_EndRpt.htm

[5] See the appendix for the full text of the explanation written by Betsy Rupp Fulwiler, the program designer and coordinator.

> *"How does water flow affect erosion and deposition?" "Does wheel size affect the distance a go-cart can travel?").*
>
> *As students are developing their conceptual understanding—as well as their scientific skills and thinking—they need graphic organizers and word banks to organize their thinking, to help them remember what they are learning, and to lead them to deeper levels of understanding as they construct and explain their own organizers (e.g., scientific illustrations, diagrams, T-charts, tables, graphs, flow maps).*
>
> *Finally, as they begin to write expository text to communicate about their scientific understanding, they need writing structures or frames to help them remember what they need to describe and explain as well as to support them in learning how to write scientifically, with clarity, accuracy, strong details, and organization.*
>
> *These three components—conceptual understanding, organized thinking, and expository writing—are developed through ongoing modeling by the teacher, practice, and constructive formative feedback.*

For each of the 18 science units used in the K-5 grades, there is a set of materials called a "writing packet" that comprises the curriculum of the Science Writing program. Additionally, the Science Writing program offers a series of after-school or summer workshops, called "science writing classes," which introduce teachers to the overall approach to the teaching of writing and use of notebooks, and which orient them to the specific writing supplements for their grade level units. There is one introductory class of 3 hours, and three 90-minute classes for each grade level. The classes are seen as integral to implementation: teachers receive a writing packet for a science unit only when they participate in a relevant science writing class for their grade level[6]. A cadre of Lead Science Writing Teachers (LSWTs)—full-time practicing teachers—helps to field-test science writing materials and meets monthly to support the ongoing process of refining the approaches, the writing packets, and the classes.

Washington state's grade level science content standards and system for assessing student achievement in science have lagged behind the district's elementary science reform. Project leaders have thus been compelled over the past two years to revise and add to their existing curriculum and professional development materials for both the foundational science units and the science writing component to bring them into alignment with state expectations.

Previous studies

We have conducted two earlier studies of the Science Writing program, and these followed from our evaluation (referred to above) of the foundational initiative to develop the K-5 science curriculum. Our first study explored the extent to which the work in student notebooks reflected benefits for students that were consistent with the goals of the program. We sampled notebooks from classrooms where program leaders felt the approach was being implemented as close to the design intention as possible. In consultation with the program coordinator, we created a set of criteria for student

[6] This is consistent with the policy of providing teachers with the science kits only when they take the workshop associated with that unit and the use of the kit as curriculum.

learning that matched program goals, and we enlisted top LSWTs to read student notebooks and assess the work against the program criteria. We took care to explore how student work compared across schools with different SES indicators and to examine the work of English language learners as well as native speakers.[7] Our second study asked about the extent to which the program's approach produces the kinds of benefits for students that are important to district leaders and the larger science reform community beyond the district. Again we sampled notebooks from classrooms where implementation was very faithful to the program, but this time we invited SPS administrators and a variety of outside experts in writing and science instruction to assess the work in student notebooks.[8] This second study also included a survey asking K-5 teachers about their teaching of science and their teaching of writing in science. For the survey we sampled teachers who had taken science writing classes and those who had not.

Together, these studies suggested that the Science Writing program, when implemented, has substantial benefits for student learning—benefits that matter to the Seattle district's own goals *and* to the reform goals of the broader field. Both studies showed, for example, that the structured writing approach seems to enhance the learning of key science concepts of the units and to support the processes of guided inquiry, and that the context of hands-on science serves as a rich foundation for building expository writing skills. (These studies also suggested that the structured approach of the program, while clearly beneficial on the whole, was vulnerable to being over-used to the extent that it could be constraining, rather than generative, for students.)

Of the teachers responding to the survey, a substantial proportion of those who had taken 2 or 3 expository writing classes (4.5 to 6 hours total) over the course of two or three years reported that they were implementing the science writing approach at least partially. Also, they reported teaching more of the science units and feeling more confident teaching science than teachers who had not taken the science writing classes. Since a substantial proportion of the district's elementary teacher corps has taken some of the writing classes, these reports were suggestive that many hundreds of students district-wide might have potential to gain observable benefit from the program. This combination of findings led to the questions that are driving the current study.

The current study of implementation and benefits to students

Our earlier studies made us curious about the extent to which teachers who had taken two or three workshops over the course of two or three years could actually implement the approaches of the Science Writing program to a degree that could be documented. We wondered what such implementation would look like, and wondered what promise it would hold for students. In designing the current study, we aimed to address the following questions:

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[7] This report is available from http://www.inverness-research.org/reports/ab2002-07_Rpt_SeattleNotebks_ElemSciWriting.htm

[8] This report can be found at http://www.inverness-research.org/reports/ab2003-08_Rpt_SeattleNotebks_ElemSciWriting.htm

A. What does implementation of the Science Writing program look like in the classrooms of teachers who have participated in an average number of science writing classes? *(To what extent do these teachers implement the science writing program as it is designed? What are the patterns or key features of their implementation, as reflected in student notebooks?)*

B. What factors influence and shape implementation in these classrooms? (*What conditions shape these teachers' science teaching and their approaches to using science notebooks? How do the Science Writing curriculum and classes interact with other influences?)*

C. What are the benefits to students of different degrees of implementation? *(To what extent do the students in non-LSWT classrooms show development in the three areas important to the program's goals (conceptual understanding in science, organized scientific thinking, and expository writing)? To what extent do students benefit in ways that are important to the broader field?)*

D. If there is implementation that is not full and faithful to the design, does such implementation provide benefits to student learning? Are there detrimental effects? *(This is what we have come to call the "apple or pork chop" question, and it is based on an analogy that probably held up more literally a hundred years ago but still makes the point today: A "half-baked apple" is not as good as a perfectly baked apple but is better than no apple at all. In contrast, while a perfectly baked pork chop is wonderful, a "half-baked pork chop" may do some harm and thus it is better to have no pork chop at all. This analogy is important to take into account when studying highly specified programs: To what extent can they be implemented so that they produce intended benefits? Can less-than-optimal implementation provide some benefits without producing negative effects?)*

The body of our report is organized around these questions.

Design of the study

The sample of "typical" teachers using notebooks in science

Our aim was to create a sample of teachers in grades 1, 3, and 5 who were currently teaching science and who had participated in a "typical" amount of professional development in the Science Writing Program. The program is designed to give teachers at each grade level access to a set of four professional development sessions (Science Writing classes) that add up to 7.5 hours. The set includes one introductory session of 3 hours and three 1.5 hour sessions focused on the specific grade level to correspond with the three science units.[9] Drawing from analysis of teacher data conducted by the

[9] Teachers who change grade levels can continue taking the grade-specific ones for their new grade level. Thus, some teachers who are not Lead Science Writing Teachers but who have changed grade levels have taken more than the basic set of four and thus have more than 7.5 hours total. There are a good many teachers who have taken science writing classes earlier than

CRESST Center at UCLA[10], we ascertained that the average number of hours of Science Writing classes taken by elementary teachers between 2001 and 2004 was 7.27, and the median number of hours was 4.5. The total number of K-5 teachers teaching in 2004-05 who took between 4.5 and 7.5 hours during that time was 94. Using this information as a foundation, we analyzed attendance rosters from Science Writing classes between 2002-03 and 2004-05 and identified those teachers who are teaching grades 1,3, or 5 in 2004-05 and who have participated in a minimum of 4.5 hours (the introductory class and at least one grade level class) during that time but who are not Lead Science Writing Teachers. This analysis yielded a potential sample of 21 teachers at grade 1, 20 at grade 3, and 17 at grade 5.

We contacted each of these teachers and interviewed them briefly to ascertain the following:

- are they actually teaching at least one district science unit this year?
- are they using science notebooks in their teaching? If so, are they using at least some of the writing-in-science strategies addressed in the Expository Writing and Science Notebooks supplementary curriculum ("writing packets") and classes?
- are they willing to provide us with a sample of notebooks for the study and be interviewed?

These interviews produced seven teachers at grade 1, four teachers at grade 3, and eight teachers at grade 5.[11]

To create the sample of student notebooks, we drew eight from each of the grade 1 and grade 5 classrooms, and ten from the grade 3 classrooms[12]. We drew these at random but took care to draw proportionate numbers of notebooks from students designated as English Learner, Special Education, and Spectrum (gifted). The following table summarizes the sample yield.

2002-03; however, we used the most recent three years because we wanted to examine typical use of notebooks in current context. A few teachers in our sample took earlier courses as well as more recent ones.

[10] The CRESST Center is conducting a study of the statistical correlation of elementary teachers' professional development participation in science and WASL scores.

[11] A few teachers were not teaching science because their grade-level partner, an intern or someone else was covering their science. Some were teaching social studies instead of science this year and plan to return to science next year during their two-year loop with students. Some were teaching science but not using the notebooks or the program's writing strategies. One had already sent her notebooks home with her students, and two declined to participate.

[12] One class set consisted of 12 so we included them all.

Table 1.
Sample of "Typical" Science Teachers Using Writing in Science

Grade level	# of teachers with 4.5 or more hrs of writing classes between 2002-03 and 2004-05	# of these teachers teaching science, using writing strategies, and willing to participate	# of student notebooks drawn from classrooms
1	21	7	56
3	20	4	42
5	23	8	64
Total	64	19	162

Measuring implementation

To assess the degree to which teachers in the sample were implementing the writing approaches in ways that matched the program's expectations, we invited Lead Science Writing Teachers who are experienced at the specific grade levels to read and analyze the work in the class samples of student notebooks. The LSWTs worked in teams, reading and discussing the characteristics of the student work in all notebooks in the sample. Researchers working with each team took notes during the discussions, sometimes asking the teachers to make their analysis and reasoning more explicit. The LSWTs then gave each class sample a rating on a scale of 1 to 4, with 1 reflecting little or no evidence of program implementation and 4 representing full implementation comparable to that of an LSWT.[13] For each class sample, teachers wrote down the evidence they observed and the reasons for their ratings. When all samples were rated, we interviewed each grade level team to capture their overall reflections on the several class samples they had read.

Program implementation has not been rated in this way before. Thus, this part of the study yields two kinds of outcomes. One is the ratings themselves, which provide some grounded perspective about what "typical" implementation actually looks like in the student work. The other is a potential new tool that the program can use, if they wish, for their own formative purposes. The rating scale that we used included four levels with very simple and general guidelines for each level; it is the Lead Science Writing Teachers' specification of characteristics of notebooks that match each level that can help create a more broadly usable tool.

Observing student learning: Two perspectives on science notebooks

To examine student learning, we studied the work in the sample of student notebooks. We brought two different perspectives to this study: Lead Science Writing Teachers and outside experts in science and/or writing.

[13] The Class Sample Rating Sheet is in the Appendix.

Lead Science Writing Teachers as representatives of program standards. Lead Science Writing Teachers are the best representatives of the program standards and practices in action. They have been working alongside the creator of the materials—some for several years, others more recently—to field test the teaching strategies, gather student samples that reflect program standards, and assist in the support of their colleagues. For this study, we involved the LSWTs in a systematic reading and scoring of student notebooks that were in classrooms where implementation was rated at a level 3 or 4.[14] For the scoring, we used a slightly abbreviated version of the same scoring guide used for scoring notebooks in the 2003 study.[15] (Some of the same LSWTs had participated in that scoring.) This scoring guide asks teachers to rate notebooks for each of three criteria on a scale of 1-4. The criteria are: conceptual understanding of the science ideas of the unit, scientific thinking and use of scientific skills, and expository writing. Additionally, we asked teachers to identify key passages in the notebooks that exemplified the scores. In this report, we present the scores and also compare the scores to those of the 2003 scores for notebooks drawn from LSWT classrooms.

Outside experts as representatives of the broader field. We invited a dozen experts in writing and/or science instruction who serve the field in a wide range of ways. Five are university scientists or science educators, two are leaders of professional development networks in writing, one is a state supervisor of K-12 science, two are science reform leaders in other districts, and two are lead science teachers in another district. As a group, they served as a proxy for "the field." They are disinterested in implementation of a particular program and came to the notebooks without a set of program- or district-based standards and expectations in mind. Rather, they brought to the notebooks their own expectations for student learning in science based upon their full repertoire of professional experience as active members of and contributors to the fields of writing and science education.

Each of the readers read a packet of six notebooks that consisted of two notebooks from each of three class sets. Most read packets from a single one grade level, though a few read two notebooks from each of the three grades. The reviewers wrote comments about each notebook (citing examples from the notebooks that prompted their comments), as well as summary comments about their packets, in response to the following questions:

1. Based on your views about what is important to learning of science and writing, what are your first impressions of the work in these notebooks?

2. What do you see in these notebooks that you believe is important vis-à-vis students' learning of the following:
    a. key scientific concepts of the units
    b. scientific thinking and inquiry processes
    c. expository writing

[14] Notebooks in the class samples rated 1 or 2 for implementation were not scorable against criteria reflecting the program's goals.
[15] The Individual Notebook Scoring Guide is in the Appendix.

3. What is absent from these notebooks, based on your views about what is important to student learning of science and writing?

4. Other comments

Following each of these reading sessions, we debriefed the groups orally to offer them a chance to share their reflections on the notebooks. During these discussions, we posed the "apple-pork chop" question explicitly: For the "thinnest" of notebooks, do you see evidence of benefits to students? Or is minimal notebook use more detrimental than beneficial?

Identifying factors influencing implementation

We entered the study on the assumption that teachers' classroom practices are shaped by a great many influences, *some* of which might be the professional development workshops in which they participate. As a way of helping us understand more about how the teachers in our sample were approaching the use of notebooks in science—and more importantly, why they were approaching it the way they were—we interviewed each teacher for 60-90 minutes. We asked them to describe and explain their use of science notebooks, to explain their thinking and their values about the learning of science and writing, and to tell us how fully they were using the district's approaches. We also asked them to rate how strong an influence various factors were on their teaching, and whether these factors tended to push them away from or toward more use of notebooks in science.[16] Such factors included the availability and quality of the writing classes and other science workshops; the teachers' own knowledge, confidence, and values related to science and writing in science; the teachers' use of writing and/or science strategies they gained from professional development from other sources; school-level conditions, such as time available for science, the priority of science and of writing in science, and help from colleagues; district priorities; and the Washington Assessment of Student Learning. For this report we use themes from the teachers' accounts and also their compiled ratings of the influence of different factors to reveal patterns underlying the teachers' use of notebooks in science.

[16] The interview protocol is in the appendix.

II. FINDINGS

The table below shows the sequence of questions discussed in this section.

Table 2.
Research questions and relevant data

Research question addressed in this section	Relevant data
A. What does implementation look like in typical (non-LSWT) classrooms?	Lead Science Writing Teachers' (LSWT) assessment of class sets of notebooks
B. What factors influence and shape teachers' use of science notebooks?	Participating teachers' interviews and ratings
C. What are the benefits of science notebooks for students in non-LSWT classrooms?	- LSWTs's and field experts' reviews of individual student notebooks. - Comparison scores from prior-year ratings of notebooks from LSWT classrooms
D. If there is implementation that is not full and faithful to the design, does such implementation provide benefits to students? Are there detrimental effects?	LSWTs's and field experts' reflections on the full range of student notebooks

A. What Does Implementation Look Like in Non-LSWT Science Classrooms?

Lead Science Writing Teachers (LSWTs) were asked to assess the degree to which the student work in class samples of notebooks reflected implementation of the program. They rated each class set on a scale of 1-4, with 1 reflecting little or no implementation and 4 reflecting full implementation comparable to that of a LSWT.

Key Findings

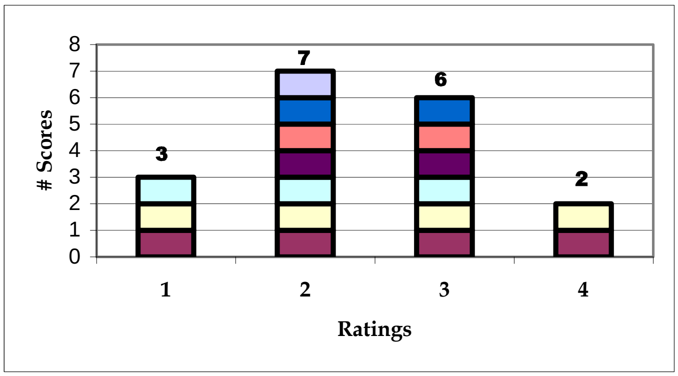
The pattern of implementation across the eighteen class samples produces a bell-shaped curve covering the range of very minimal to full implementation. Of the eighteen sets, eight were rated at implementation level 3 or 4 on a scale of 1-4, and ten were rated at level 1 or 2.

The two class samples rated at level 4 reflect implementation so faithful to the program that they are essentially indistinguishable from those of an experienced LSWT. Level 4 sets showed *use of all components* of the expository writing program in a way that *purposefully served student learning*.

The thirteen sets rated at levels 3 and 2 vary considerably in the extent to which they reflect *partial* (vs. consistent), *purposeful* (vs. mechanical), and *pure* (vs. a blend) application of the program's writing strategies, with the six sets rated at level 3 reflecting quite strong and consistent implementation of the program's approaches. For the three class sets rated at level 1, LSWTs saw virtually no evidence of systematic use of notebooks in science.

As can be seen on the graph below, the overall pattern of implementation resembles a bell-shaped curve. Of the eight class sets rated in the top half, six were rated at level 3 and two at level 4. Of the ten class sets rated in the bottom half, seven were rated at level 2 and three at level 1.

Figure 1.
Ratings of class sets: All grades



LSWTs' explanations of ratings

In explaining their ratings, the LSWTs named the kinds of evidence that they were looking for. To gain a high rating, the notebooks had to have evidence that the teachers were "faithfully following the writing packets." There were two broad criteria that constituted this faithful use:

<u>1. Presence of the "basic components"[17] of the expository writing and science notebooks program</u>. The LSWTs emphasized that they expect the "basic components" to be in place and to be used consistently and with seriousness. These basic components include such features as:

- "setting up the notebook" (e.g., page numbers, tables of contents, dates, with all entries in sequence so that the student can easily refer back to materials)
- consistent use of focus questions (e.g., *How does length affect pitch? What do you think causes a slide whistle to make different pitches? How can we make sound with strings?)*
- disciplined documentation of data—well-labeled charts of trials and observations, diagrams and drawings
- use of writing frames appropriate to the focus question *(e.g., I know this because—* to support a conclusion with data*)* and graphical organizers to guide thinking *(e.g., T-chart for comparison)*.
- evidence of word banks used to teach accurate use of scientific vocabulary

[17] All quotations are from debriefing interviews with LSWTs or their written comments on notebook rating sheets.

2. Purposeful use to serve student learning. Beyond these components, the LSWTs expect the focus questions, writing frames, and other scaffolds to be used purposefully, not mechanically, in ways that consistently support "the thinking and the learning." For example, they looked for evidence that students make well-reasoned predictions, that they consistently and thoughtfully use data to support their own conclusions, that they explain and correct misconceptions or wrong predictions when they occur, and that they frame reasonable next questions to ask based on what they have learned. LSWTs also expect to see a substantial amount of writing for each lesson, including evidence that students who are obviously struggling with the mechanics of writing or the science concepts are given adequate time to explain their thinking in writing.

Additionally, the LSWTs noted that the writing goes hand-in-hand with the science: "You have to do science well before you can write in a thoughtful way. If the science is confused, the writing is too." Class sets of notebooks where there seemed to be substantial gaps in science lessons or inconsistencies in writing opportunity for lessons were rated low. One team commented that notebooks need to have "evidence of a flow through the unit. The whole point of keeping notebooks is to show this."

Distinguishing among the four levels of implementation

In a few class sets, LSWTs encountered science content not covered in the district's units, usually in the form of photocopied materials stapled into the notebooks; or they saw focus questions not from the program's packets; or they found writing entries or graphical organizers that were from a different writing program in the district or some other source. LSWTs generally viewed these unfavorably, which suggests they brought a very strong "program fidelity" perspective to the task of rating class sets.

The LSWTs could readily define a Level 1 set as not having the basic components; these notebooks appeared to be used "randomly" or as "just scratch paper." Often notebooks from these sets had very few entries, perhaps three or four sheets per notebook had any writing on them. Level 2 class sets were often characterized by inconsistent appearance of "the basic components," for example, only occasional focus questions, some frames left empty or questions unanswered, some missing page numbers, incomplete diagrams or non-labeled drawings. Level 2 notebooks could also exhibit what one person called "frames gone haywire," in which all notebooks in a class set were fully scripted or had exactly the same observations and even opinions. One reader noted: "In a good use of frames it helps students get started but the students enter their own process, thinking, ideas, conclusions, evidence. Even with group modeling you want each student to do their own thinking." We wish to emphasize that class sets that were rated at level 1 or 2 for implementation of this particular program did not show evidence that participating teachers were implementing an alternative system for using science notebooks; rather, they showed evidence of partial or inconsistent use of the Expository Writing and Science Program approaches.[18]

[18] We remind the reader that we assume that the student notebooks alone do not fully reflect the instruction in science.

In level 3 class sets, there was an overall more orderly sequence and consistent use of the basic components, including the focus questions, data charts filled with observations and measurements, well-labeled diagrams, as well as quite a bit of student writing that responded to focus questions. What distinguished these sets from those rated at level 4 was a still less-than-optimal use of notebooks for pushing the students to "think and write like scientists." Raters sometimes characterized this level 3 pattern as "going through the motions" or showing an emphasis on "process" (doing the science activities, having the notebook components in place) rather than "outcome" (thoughtfully approaching the investigation, gathering data and using it to draw conclusions and to explain, and building scientific concepts across several lessons). As one rater noted, "you have to have the basic components to get a 3, but more than the basic components to get a 4." Ratings of this level of purposeful use often included evidence of teacher monitoring that caused students to correct conceptual inaccuracies or explain their reasoning more thoroughly.

Below are excerpts of notebooks from two class sets (1st grade) that reflect what LSWTs see as one important difference between a class set rated 3 and one rated 4. The first sequence of statements from different students' notebooks within a class set rated at level 4 shows what LSWTs consider to be appropriate scaffolding of student work for first grade, i.e., using the program's writing frames while requiring students' independent thinking about what the investigation has taught them. .

> *[Focus question: What materials can balls be made of and how should they be constructed so they can roll and bounce?]*
>
> *Notebook A –*
>
> > *My Ball was a Bad Bouncer because it is made out of Clay. It Was a good roller because its round.*
>
> *Notebook B –*
>
> > *My ball was a bad buncer because it's has bums on it It was a good roller because it's smuh.*
>
> *Notebook DF –*
>
> > *My ball was a bad bouncer because ha da tishyou.*
> > *It was a good roller because it was a sphere.*

The second sequence of statements, from notebooks in a different class set rated at level 3, suggests to the LSWTs that the teacher is over-using frames because the students are copying exactly the same sentences and entering "will" or "will not," rather that creating a statement with their own data.

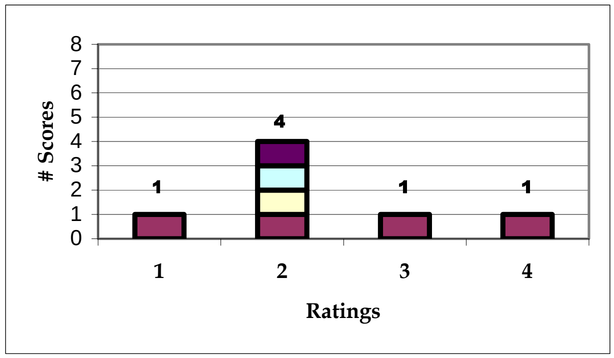
> *Notebook A —*
>
> > *I predict adding rubber bands to my ball <u>will</u> hellp it bounce.*
>
> *Notebook B—*
>
> > *I predict adding rubber bands to my Ball <u>well</u> help it bounce better.*

Variations in implementation across grade levels

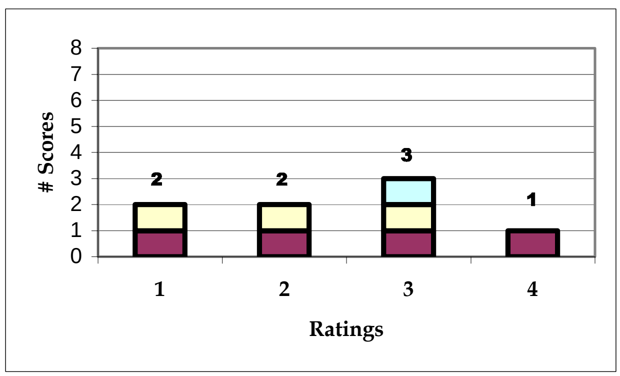
As shown in the sequence of graphs below, there were slightly different patterns of implementation at grades 1 and 5. This difference does not seem to be due to differences in standards across the teams of raters; their written and oral explanations of ratings are nearly identical. Probably there are differences within the sample of participating teachers.

Figure 2.
Ratings of class sets by grade level

First Grade

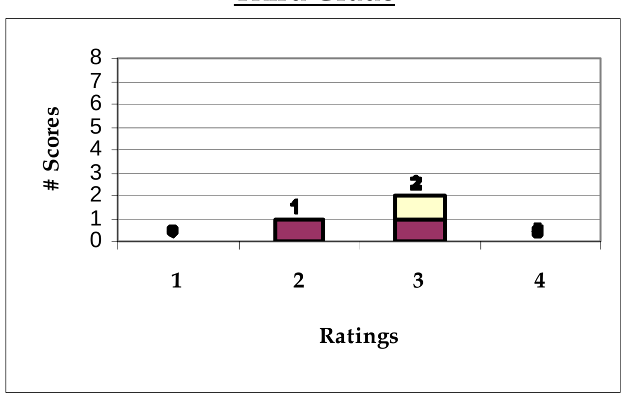


Fifth Grade



In grade 3, where we were able to rate only 3 of the 4 class sets, there was a tendency for ratings to cluster in the middle range but there are too few to suggest a pattern.

Third Grade



B. WHAT FACTORS INFLUENCE AND SHAPE TEACHERS' USE OF SCIENCE NOTEBOOKS?

To enhance our understanding of how and why the teachers in our sample approached the teaching of science and the use of science notebooks as they did, we interviewed them in depth.[19] As part of the interviews we asked them to rate the strength of various influences on a scale of 1-5, and to say whether those influences pushed them toward, or away from, implementation of the Science Writing program's approach to teaching writing in science. Our aim was to find out what the whole group of teachers had in common as well as to explore what differences there might be between those who were implementing the science writing program more or less fully.

Key Findings	For the teachers in this sample, the lack of time available for science, because of its low priority in schools, created pressure against full implementation of writing in science. Personal characteristics of the teachers exerted stronger positive influences on their implementation of the science notebooks program than school-level conditions, district policy, or the state assessment system. Teachers' levels of relevant knowledge and skill primarily, and their belief in the value of this program for learning science secondarily, gave them the confidence to try the science writing program's approaches despite the low priority of science in their schools. Strong personal confidence or belief shaped the extent to which some teachers made the effort to implement the program fully despite time pressure. The district's high quality professional development offerings in science and writing in science made a critically important contribution to the knowledge and confidence that teachers needed. Most teachers would like additional support that is different from, but builds on, the workshops. Collegial interaction around science at the school level was virtually non-existent. These teachers would like school conditions to improve *vis a vis* the teaching of science.

Teaching experience

The sample of teachers reflected a wide range of teaching experience. Of the seventeen teachers, eight are within their first 5 years of teaching and seven have more than 10 years' experience. Additionally, five of the seventeen were in their first year teaching at the grade level and thus were using the science units for the very first time. Particularly for teachers with little overall teaching experience, the first time through one of these hands-on units can be quite challenging. As a group, the teachers whose class sets showed less full implementation were only slightly less experienced than the others.

[19] Of the 19 teachers whose notebooks we collected, we were able to interview 17. The protocol, including the set of 15 influential factors, is in the appendix.

Teaching experience did not seem to play a strong role in level of implementation, although in interviews a couple of the newer teachers mentioned that they believe they will improve in their teaching—and management—of these very involved units as they go through them more times with students.

Factors influencing use of science notebooks

The condition of limited time

At the outset it is important to remember that all seventeen teachers shared some degree of underlying personal belief that science is an important subject to teach, and most of them—especially the less experienced teachers—told us that they are not as comfortable teaching science as they are other core subjects. At the same time, we note that 82% of the teachers said *time available for teaching science* was a strong influence that pushed against their use of science notebooks; this was the only strongly negative factor for the whole group. Thus, for nearly all of these teachers, teaching science at all requires a *personal* commitment to find the time.

Given this, what were the factors that caused teachers to make the effort to teach science and to implement the science writing program?

Individual knowledge and confidence, supported by professional development

Across the whole group, the characteristic that teachers had most in common was that a combination of individual knowledge and beliefs, supported by availability of high quality professional development, pushed them to at least make the effort to teach science and use writing notebooks in science. The table below shows ratings for the group of 17.

Table 3.
Factors associated with individual teacher efficacy and value of professional development

	% teachers saying this is a strong influence*		**% saying this factor increases use of science notebooks**	
Factors that influence teachers' use of science notebooks	Implementation level 1 or 2	Implementation level 3 or 4	Implementation level 1 or 2	Implementation level 3 or 4
- own beliefs about the value of writing in science	100%	71%	100%	100%
- own overall level of knowledge and skill in teaching writing in science	78%	100%	78%	71%
- own overall confidence in teaching science	67%	86%	67%	86%
- amount of PD in science writing and/or science	89%	100%	100%	100%
-quality of PD in science writing	78%	86%	100%	100%

** Rated 4 or 5 on a 5-point scale*

In interviews, teachers made links between the professional development and their personal confidence to teach science and writing in science. All but two of the teachers whose class sets showed low implementation had low confidence in their science knowledge and ability to teach science. Having the professional development enabled them to take the first steps toward teaching science and using the writing strategies. The professional development served two functions: It gave them the confidence to try integrating writing into science and give them a clear model to follow. This comment reflects the experience of several teachers:

> *The science and writing classes were really helpful giving me a chance to try out some of the lessons and a way to approach teaching the lessons. It would've been overwhelming without the training. I couldn't have done it without the classes.*

For two of the teachers whose implementation was rated lower, the professional development had a weaker influence.

Some of the teachers whose class sets were rated higher for implementation had somewhat greater underlying confidence and knowledge in their ability to teach the science units. Nonetheless, all of them told us the professional development was valuable in enabling them to teach writing in science effectively; five of the seven told us it was extremely valuable. Again, the classes provided a clear model for using the notebooks.

Teachers' interest in additional professional development

We asked the teachers whether they would want more professional development in science writing and, if so, what type of support they would value. Teachers were divided in their responses. Among the nine teachers whose class sets were rated as lower for implementation, five said they would probably take more classes. Of the teachers whose class sets were rated more highly, four said they might be interested in more classes. Across the whole group, there was a substantially stronger preference for ongoing professional support more connected to their teaching situation—for example, mentoring or grade cluster meetings related to teaching specific units—and nearly all of them said they would like regular opportunities to examine and assess student work in notebooks with colleagues.

The teachers' responses to this question reinforced our sense that the district science policy and writing classes were not the primary motivator for using notebooks in teaching science. Rather, the classes made it possible for teachers who were committed, but not well equipped, to strengthen their teaching of the district's science units and to add to those units with the systematic writing strategies from the notebook classes. The teachers' responses also reinforced our sense that the writing classes are the first step in professional development; additional steps that are different from the writing classes are likely needed for fuller implementation across a larger percentage of teachers.

Commitment to fidelity in implementation

Overall, teachers whose class sets reflected less implementation said they used the writing prompts and strategies 40-80% of the time, as opposed to 80-90% of the time for those with higher implementation. Teachers whose class sets were rated higher for implementation had greater tendencies than the others to stick with the commitment to teach writing in science even under the pressure of time, and also to employ the program's curriculum and strategies with as much fullness and fidelity as possible. Some of the more confident and experienced teachers made this commitment out of a desire to test the effectiveness of the program. One put it this way:

> *Since I am in the first year of Betsy's program I am trying to follow this as is written. I always use the prompts—trying to find out how effective the program is—the only way I can find that out is to do exactly what's being suggested. Next year I will modify the program, if there are things I don't like.*

Other teachers followed the program fully because they lacked the confidence to make changes. For the following teacher, for example, the professional development in both the science units and the writing, combined with her personal commitment to making the time for her students to write, resulted in higher implementation:

> *I teach the units completely, I don't pick and choose—I don't know that much about this stuff to do that…All those templates [from the science writing packets] are really wonderful—and I refer to and try to model them. I've really adopted the NSF strategies—these have helped me, I have so far to go.*

In contrast, some of the teachers whose class sets showed low implementation said that they succumbed to time pressure and did not use notebooks as much as they wished, or did not emphasize writing as much as other modes of learning and communicating. Some ratings of partial implementation stemmed more from a lack of confidence and commitment to the time required for students to complete their writing, than from a deliberate choice not to follow the program. Here is one teacher's view:

> *I try to incorporate them with each investigation—do a prediction and then follow up with a reflection—that's my goal. I'm not always successful—get carried away with the investigation and management and run out of time. This year, I used them less than in previous years. My kids are really good about verbalizing, have a harder time getting it down on paper—we spent more time on discussions.*

More than half of the teachers in the lower implementation group tended to blend writing strategies they had encountered in other professional development with what they were learning in the science writing classes; in other words, fidelity to this single approach was not as high a priority for them. One teacher, for example, said "I just take ideas from everywhere and put them into my teaching." Teachers referred to writing strategies that came from NUA literacy training, Powerful Writing, the Puget Sound Writing Project, Write Track, and Step up to Writing. A few of these same teachers also altered the science curriculum by adding other materials to the units or substituting their own unit for the district's. For these teachers, confidence and time were less of a problem; rather, they were making choices about how to incorporate professional development from multiple sources.

We wish to offer our researchers' perspective on the preceding finding, lest it be over-interpreted as meaning that blending of other strategies will necessarily diminish students' learning opportunities. The LSWTs who rated the class sets brought very strong fidelity criteria to the notebooks, as we expected them to do. Thus, seeing different strategies affected their assessment of program implementation. And while notebooks rated at levels 1 and 2 showed partial implementation of this program, those notebooks did not show evidence of a competing system for integrating writing into science. Rather, some of the notebooks showed partial (and usually, quite minimal) use of strategies taken from multiple approaches to writing. Furthermore, two of the teachers whose notebooks were rated higher for implementation integrated strategies for art and writing, as well as some additional science opportunities, into their units and notebooks, and these did not interfere with the raters' assessments. Thus, we do not make inferences about the advantages or disadvantages of blending.

Notably, when asked about the value of notebooks for teaching science, none of the teachers whose class sets rated lower talked about the benefits to students' *writing* development; rather, they emphasized science learning. Among those whose notebooks showed higher implementation, five of nine talked about the benefits of the Science Writing program to students' writing development, as well as to their science learning. It thus appeared to us that teachers who believe in the value for *both* are more likely to do an internal cost-benefit analysis that justifies taking the time that the science and the writing require.

The table below reinforces the finding that some teachers with lower levels of implementation were somewhat less strongly (but still positively) influenced by the program and its materials than those with higher implementation.

Table 4.
Factors associated with teacher agreement with the program

Factors that influence teachers' use of science notebooks	**% teachers saying this is a strong influence*** Implementation level 1 or 2	3 or 4	**% saying this factor increases use of science notebooks** Implementation level 1 or 2	3 or 4
- own level of agreement with the appropriateness of the writing strategies promoted in district classes	44%	100%	78%	71%
- degree of fit/appropriateness of district's writing packets with the science units teach	33%	57%	78%	71%
- district expectations for science learning	33%	71%	78%	71%

** Rated 4 or 5 on a 5-point scale*

The effect of specific science units on the use of notebooks

There was little difference across the whole sample of teachers in how much time was spent teaching science. The teachers told us they typically spend 2-3 hours a week on science while teaching a unit and spend 5-6 weeks on a unit. However, the teachers did point out that specific units vary in two ways that can affect their implementation of the science writing program.

First, some units are much more time-consuming and difficult to manage than others because they include multiple investigations that involve setting up of materials, many student trials, and much data collection. Balls and Ramps in first grade, and Land and Water in fifth grade, stand out for these teachers—and these units have the added management factors of balls bouncing around in rooms full of 6-year-olds and 10-year-olds creating flowing mudslides. Teachers can find it difficult to shift the students from these highly engaging activities to the writing. Some teachers feel they are lucky to find time for the data recording, and do not find the time for the reflective, meaning-making writing. And these are characteristics of notebooks that raters notice.

Second, teachers say that some units are simply more amenable to interesting writing than others. Some first grade teachers feel that Balls and Ramps is overly statistical, and that Weather and Organisms better lend themselves to written expression. A third grade teacher told us that Sound lends itself to writing much more than Plant Growth or Rocks and Minerals. The teachers who see these differences bring different judgments to the program's writing packets, sometimes questioning the value of the writing—particularly if the packet expects one or more writing tasks for every single lesson.

We note again that the teachers in our sample were much more inclined to think of the writing as serving the science rather than the reverse, so the extent to which the units lend themselves to writing makes a difference when teachers are making choices about use of time. Both of these unit-related factors can influence—one way or the other—an individual teacher's personal commitment to making the effort to fully implement the program.

The relatively weaker effect of school conditions

There are very few differences across the whole sample of teachers on the influence of school conditions. Their ratings suggest that school conditions have a weaker influence than individual factors combined with professional development.

Table 5.
Factors associated with school conditions

Factors that influence teachers' use of science notebooks	**% teachers saying this is a strong influence*** ***(All teachers)***	**% saying this factor increases use of science notebooks** ***(All teachers)***
- priority of science at my school	53%	53%
- emphasis given to science writing at my school	41%	53%
- help from school colleagues	30%	41%
- students' skill level	59%	30%
- standardized test demands (e.g. WASL)	41%	53%

** Rated 4 or 5 on a 5-point scale*

In interviews, what stood out for us is that 16 of the 17 teachers receive so little support at the school level for the teaching of science that they have come not to expect it. "It's a non-issue, it just doesn't happen," said one. We note that the relative overall weakness of school priority as an influence can actually have a somewhat positive effect for science: Several of these teachers are teaching science (and using notebooks at least to some extent) despite the fact that many of their colleagues are not. On the other hand, the experience of two of the seventeen in our sample points to the potential for positive school priority to have a beneficial effect. One said science is a high priority for her school, and one said writing was a high priority. They see either priority as being helpful in justifying the time that they spend, and both of their class sets were rated higher for implementation.

Except for the teacher who teaches in a school where science is a high priority (and one other teacher who team-teaches one expanded science unit), none of the teachers in our sample talk with their colleagues about the teaching of science, even informally. A few of the teachers did not know who else teaches science in their school. Because there is so little collegial interaction, teachers tended to rate it as a weaker overall influence on their teaching than other factors. However, five of the nine teachers with lower implementation told us that their isolation from colleagues negatively affects their teaching of science, and three of the higher implementers said the same thing. Some told us that they wish they would talk more about science teaching at their schools; one said "I would like to have the kind of conversations about science that we have about reading, but we don't."

With respect to the influence of WASL, some—but not all—of the teachers speculate that it *may* raise school-level priorities for science, particularly in the 5th grade. However, at the individual level, most say they are quite modestly influenced by the WASL.

In sum, the *will* to implement the science writing program stems primarily from individual teachers' values about the importance of science and their belief in the ability of writing to enhance science learning. The *capacity* to implement the program stems primarily from their individual knowledge, skill, and confidence; to a great extent, these capacities are developed and reinforced by the professional development and program materials that give teachers a model they believe they can follow.

C. What are the Benefits of Science Notebooks for Students in Non-LSWT Classrooms?

To address this question, we analyzed LSWT's ratings of student notebooks in class sets against the program's own criteria for student learning. We also analyzed the outside experts' assessments of the extent to which the work in notebooks reflects what they believe is important in the learning of science and writing.

Key Findings	LSWTs' ratings of individual student notebooks on a cumulative scale of 3-12 show that this sample of student notebooks reflects the full range of student development for the three criteria—conceptual development, scientific thinking, and expository writing—with scores clustering around levels 6 (developing) and 9 (adequate). There were no differences in average ratings for the different grade levels. Notebooks that received higher ratings (9-12) showed evidence that students were mastering scientific vocabulary and concepts, using scientific processes and skills for purposeful learning, using notebooks for data collection and retrieval, and composing explanations developed with data. Notebooks receiving lower ratings (3-6) were often characterized by incomplete work or short responses. LSWTs inferred that lower ratings sometimes resulted from students having too little time for discussion in preparation for writing or for completing writing. When compared to ratings of notebooks from LSWT classrooms in 2003, the ratings for these non-LSWT notebooks show strong similarities. This suggests that full implementation by non-LSWTs produces a similar level of student work to that produced by LSWTs' implementation. Field experts found that these notebooks reflected a very wide range of student work. They observed that many of the notebooks showed strong evidence of authentic work in science, and of writing and scientific inquiry processes working together for the mutual development of both areas. They also observed a pattern in a number of notebooks of "pat" answers, overly specified structuring, or minimal student "grappling" with causal conjecture and other meaning-making efforts. On the whole, the field experts believe students are benefiting substantially from the opportunities to use notebooks regularly as a context for developing in both writing and science.

LSWT ratings of student work in science notebooks

We asked the LSWTs to read and assign ratings to individual notebooks from class sets that were rated at level 3 or 4 for implementation. We reasoned that notebooks in class sets rated as 1 or 2 would not be ratable against the program criteria. The LSWTs agreed that the notebooks in those class sets did not have sufficient evidence of teaching science or using writing in science to be able to make any inferences about benefits to students. *An important note: We want to clarify that neither we as researchers nor the LSWTs assume that one can make reasonable inferences about the teaching and learning of science from examinations of the notebooks in those class sets rated as 1 or 2 for implementation of the writing-in-science aspect of the program. As one person said, "not everything is in the notebooks, and we don't know what other ways students experienced science."*

For first grade, 16 notebooks in two class sets were rated; for third grade, 15 notebooks in two class sets were rated[20]; and for fifth grade 31 notebooks from four class sets were rated; thus, a total of 62 individual notebooks were rated.

The rating criteria

For the rating of individual notebooks, we used a modified version of the scoring rubric we developed for earlier studies.[21] This rubric includes three broad criteria reflecting the program's aim to enhance the teaching of both science concepts central to the units and scientific thinking and inquiry skills, and to enhance students' development in expository (explanatory) writing skills, with an emphasis not on mechanics and spelling, but rather on logical organization of ideas, development with scientific detail, and use of technical vocabulary. The table below shows the four levels at which each of three criteria could be rated, with the sum of these becoming the total score. Notebook ratings thus ranged from 3 to 12.

Table 6.
Summary of criteria for rating work in individual notebooks

	Rating Level			
Criterion	1	2	3	4
Conceptual development and understanding of "big ideas" of unit	limited	developing	adequate	full
Scientific thinking and purposeful use of inquiry skills and processes	limited	developing	adequate	skilled/ purposeful
Expository writing—development, organization, scientific vocabulary	limited	developing	adequate	fluent and skillful
Total Scores	**3**	**6**	**9**	**12**

[20] 10 in one class set and 5 in the other.
[21] A copy of the rating sheet is in the appendix.

Each notebook was scored by one LSWT; these same LSWTs had already read and discussed with a partner those same notebooks in the process of rating class sets for implementation. They were thus familiar with the broad patterns of work and were now examining evidence of individual learning and development in science and writing.

LSWT assessments of the work in notebooks at different levels of development

We asked the LSWTs to explain their ratings and identify key passages in the notebooks that reflected their assessment of student development in these areas.

Notebooks that were rated in the 9-12 range (adequate to full) had plentiful writing that was detailed and organized. In these notebooks the growth and clarity of conceptual understanding could be observed in the writing across most sequences of lessons, as well as in culminating assignments that assessed what students have learned. LSWTs referred very often, when describing student work in these higher rated notebooks, to the presence of conclusions that were fully and accurately supported with data. LSWTs also see evidence that students were able to refer back to different places in their notebooks to locate the data they need to support a conclusion. These sets of skills offered LSWTs evidence of a high level of student development against all three criteria. LSWTs expected to see this level of development at all grade levels, whether it was a first grader explaining how they know that balls roll faster down steeper ramp, or a third grader explaining how they know that tighter strings make higher pitched sounds, or a fifth grader explaining how they know that sand, clay and boulders form different patterns of erosion.

Notebooks rated at level 11 or 12 (full development) showed great consistency throughout the notebook, with students responding directly to the focus questions with quite developed answers that reflected their comprehension of the scientific process and concept of the lesson. For example, in the fifth grade notebook from which the following excerpt was taken, the LSWT rater noted that the writing across multiple lessons in the Land and Water unit was "well organized and data is used clearly and accurately in conclusions." For a series of three trials with a stream table, the student had created a data table with measurements in centimeters for all three streams for five variables: depth of stream, width of stream, width of deposited soil, length of deposited soil, and depth of soil dropped at end. The student had conducted the three trials, creating a detailed drawing of each, with labels showing the stream, the soils of several different kinds (e.g., gravel, clay) as well as a legend. For each trial there was also a written explanation of the result, blending qualitative observation matching the details in the drawing with numerical measurements recorded on the data table. The following writing accompanied "Rushing River," the second stream:

> *Greater water flow increases erosion because I had a wider stream channel. To support this in lesson 4 the stream channel was 6 cm wide and in lesson 10 the stream channel was 6 ½ cm. There was also more gravel in the stream bed. Greater water also increases deposition. For example, the delta was deeper and wider, there was more soil in the bucket, and there was more soil in the sample. To prove these things the delta*

was 15 cm wide and 1 cm deep in lesson 10 but the delta was 3 ½ cm wide and ½ cm deep. Also I saw more soil in the bucket and in the sample.

The rater also noted that the assessment below, which followed a series of written predictions, tests, and observations, "demonstrated strong conceptual understanding":

Assessment D

Plants in the stream table reduced erosion because there was hardly any dirt in the sample and in the bucket. Removing plants increased erosion a little bit because I saw a small stream channel and a little bit of dirt in the runoff. People could plant grass in the hillside. I think because our experiment had grass and there was hardly any erosion.

The following excerpts are from a first grade notebook rated at <u>level 9</u> (adequate), meaning that the work showed evidence of quite strong understanding and skill but with some remaining inconsistencies. Student work appeared on 22 pages, most of which were dated and included focus questions. The work included drawings and lists of key properties of balls, tables of data from trials (e.g., measuring bounce heights of balls made from different materials), diagrams (e.g., ramps for rolling balls), predictions and then reports of balls' behavior based on tests, a definition of a fair test, and a statement of what the student would do next to test a behavior of balls. Several other entries showed the student had a strong grasp of important concepts. The rater said about the following excerpt, for example, that the "student explains why the ball rolls straight. The student understands that shape and texture are properties which affect the way a ball moves":

What properties affect a ball's movement?[22]

My ball rolls straight because it is spherer and it is a vere smooth.

In contrast, the rater noted that in the following excerpt, the student's "'because' statement" showed less-than-full grasp of properties of balls that make them roll: while smoothness is a factor related to rolling, rubber is not (rubber is a property important to bounciness, a different behavior.)

The rubber boll is a good roller. It rolls well because it is mad awt fo rubber. And it is good at rolling because it is smooth.

Notebooks that received <u>scores of 6 and 7</u> (developing) typically had substantially less volume of work than those at levels 9-12. LSWT raters noted that the student work in these notebooks showed evidence of the following:

- conceptual growth across some sequences of lessons, but not most or all. Evidence of conceptual growth could be in the form of a well-reasoned prediction about what would likely result from the next investigation based on the last one.

---

[22] This focus question is cut out and glued to the top of the page; the student has circled the words "properties," "affect," and "movement." The LSWT raters cited the use of focus questions and circling of key words as evidence of program implementation.

- partial conceptual understanding. This could be in the form of partially answered questions (a summary without a conclusion if a conclusion was asked for, or a partial summary) or explanations that were partly accurate and partly not, or were accurate in some lessons and not others.
- some use of scientific skills but with inconsistency. Charts could be partially filled in or diagrams partly labeled; conclusions might cite data occasionally but not often; predictions often did not include the reasoning behind them.
- Scientific vocabulary might be used accurately sometimes and not other times, or some terms essential to the unit concepts might be used but not others.
- Written explanations or conclusions might address the focus question sometimes and sometimes not; some written pieces may be developed with data and details, as well as the best logical order (an effective comparison, for example), but some are not.

An LSWT rater remarked on the following excerpt, from a fifth grade notebook rated as a 6, "Concepts are emerging but rough." This notebook had at least a bit of writing about most lessons:

> *How will the rocks affect the flow of water and erosion?*
>
> *Prediction: I think that when the big rock is in the stream the water wont go and it will stay there and make a pound.*
>
> *[drawing partially labeled]*
>
> *The water moved the rock some of them sink and some of them were moved. My priction was wrong.*

Similarly, in the excerpt below from a third grade notebook rated a 6, where the student was responding to a curriculum based assessment (CBA), the LSWT rater commented that conceptual understanding was at a developing level:

> *CBA: How does the lenght of an objec? Explain your thinking and use evidc from experiments.*
>
> *The length of the object affects the sound by the vibrations are fast when its shorter. The vibration are slower when its longer. The longer the oject the lower the pich the store the oject the higher the pich. I know*

Notebooks scoring at the <u>3-4 level</u> (limited) often included very little writing of sentences or paragraphs, and included partial charting and diagramming of data and observations. There was a "bits and pieces" feel to the body of work in these notebooks. For example, they might include some focus questions but very few written responses, or some scientific vocabulary or labeling but without written-out explanations that show evidence of understanding. There are often single statements without details that give evidence of conceptual understanding. These notebooks sometimes had significant gaps where there was no writing about a sequence of lessons. These notebooks reflected an effort to draw at least somewhat from the strategies of the program but without the time needed to follow through.

The following excerpts are from a third grade notebook rated as a 4, with criterion scores of 1 for conceptual understanding (limited), 2 for scientific thinking (developing), and 1 for writing (limited). The notebook was very sparsely used, with many focus questions copied in but not answered or answered incompletely. Here is an example where the student began a response to a question involving an investigation of a simple stringed instrument where students can move a part to tauten the string:

> *What can you do to make louder sounds from the string?*
> *Variables-what has changed?*
>
> *Whe you move brige it makes it louder.*

Later in the notebook, the student responded to a CBA, again with a partial response that the rater assessed as showing limited conceptual understanding:

> *CBA: How does the length of an objet affect the sound produced by objet? Explain your thinking and use evidence from experiments.*
>
> *The length of the objet affects the the sound by the pitch and how low the pitch means the sound. ~~The sound is lower~~*

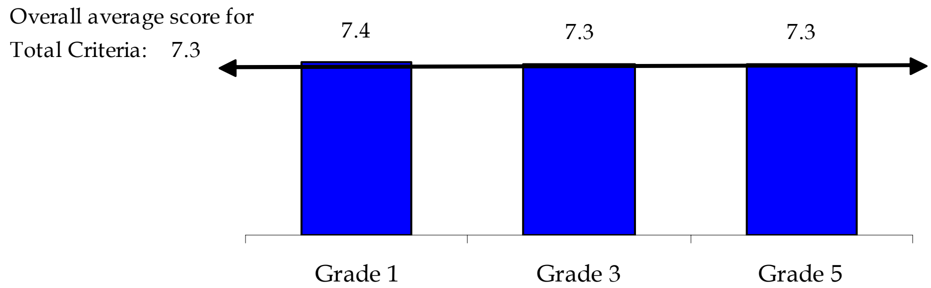
In this same notebook, the LSWT rater noted that the student demonstrated the ability to make a 2x3 data matrix with three rows for trials with three lengths of nails and 2 columns for predicted sounds and observed sounds, to do the trials, and to begin recording predictions and results. The matrix is partially completed with notes on results. The evidence of this skill in an otherwise very sparse notebook served as evidence of developing skill (level 2) in scientific thinking and inquiry processes.

On the whole, it was practically impossible for a notebook with sparse writing to earn a high rating (9-12) because it was the fullness and clarity of the writing that ultimately conveyed the level of understanding. Occasionally there were clues in "thin" notebooks that the work in the notebook did not reflect the student's overall level of engagement or understanding in science: these could be teacher comments (e.g., "I wish you would write more in your notebook because you are such a good contributor to class discussion"), or could be quite elaborate drawings that showed a strength in visual explanation but an absence of written explanation, or might be handwriting that revealed such difficulty with the physical act of writing that communication suffered. As a rule, the LSWTs avoided making inferences about the instructional practices beyond what they saw in the notebooks. However, they questioned whether students whose notebooks were at the limited (3-4) and developing (6-7) levels had had enough time to participate in class discussion during and after the investigation before writing in their notebooks, and enough time to complete their writing.

Distribution of individual notebook ratings

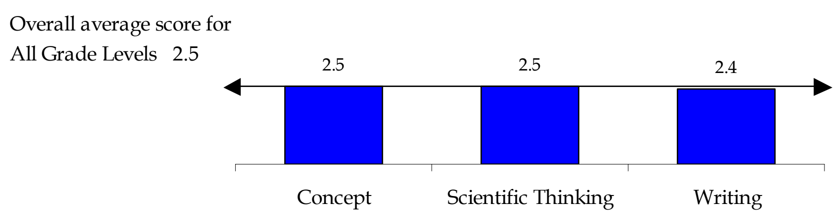
The graph below shows the average total ratings for all criteria by grade level. Note that there are no differences across grade levels.

Figure 3.
Average ratings compared by grade level



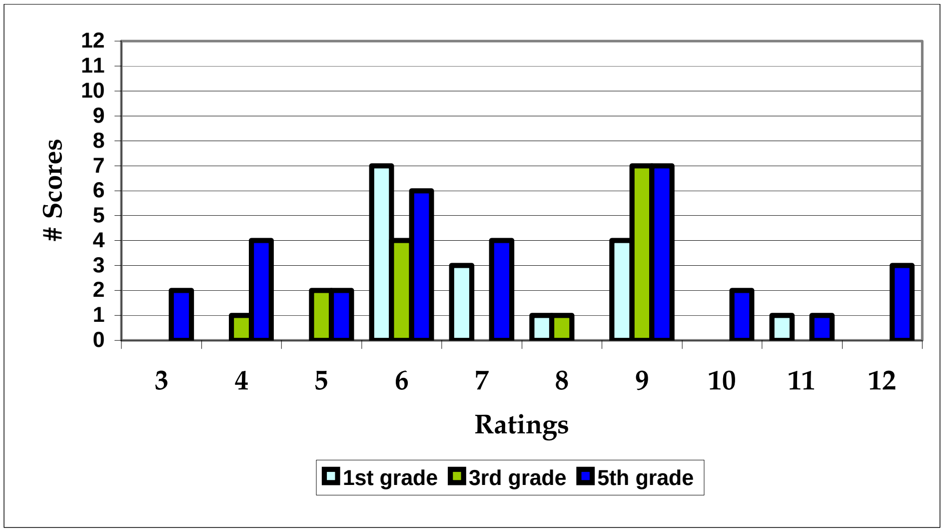
The graphs below show the average ratings for each of the three criteria. Note that there is essentially no difference in student development across the three areas. This same pattern prevailed for all three grade levels.

Figure 4.
Average ratings for each criteria for all grades



The following graph displays the full distribution of notebook scores. As might be expected because of the small differences in scores across the three criteria, scores tend to cluster close to 6 and 9, with smaller numbers distributed toward the ends of the scale. This graph suggests that the average score of 7.4 (shown above) is best understood as representing a mid-point between two peaks in the curve at around 6 and 9; that is, students were more likely to receive a score of either 6 (developing) or 9 (adequate) than a mixed score of 7 or 8. More generally, this graph shows that, within the class sets rated at levels 3 or 4 for implementation of the program, there is the full range of individual student development.

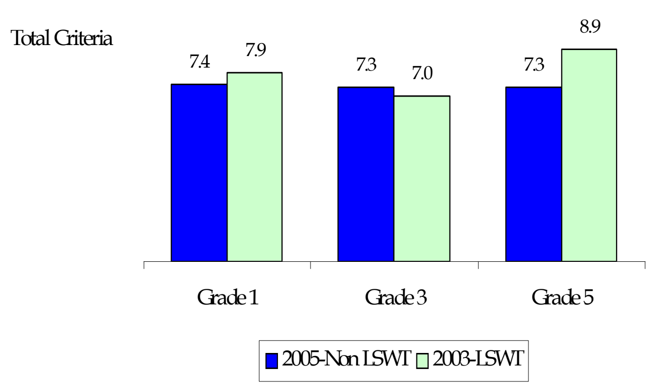
Figure 5.
Distribution of Individual Notebook Scores



Exploratory comparison of ratings of non-LSWT students' notebooks to those of LSWT students' notebooks

In 2003, we collected a sample of 60 notebooks from LSWTs' classrooms in schools with a wide range of SES conditions; the sample included 20 notebooks for each of grades 1, 3, and 5. We invited accomplished elementary science teachers who are not part of the program to apply a version of the same rating scale (a longer version with criteria spelled out more fully) to these 60 notebooks. Below we compare the overall ratings of the LSWT students' notebooks in 2003 with ratings of the non-LSWT students' notebooks in 2005 at the same grade levels. The results show a difference of 1.6 points in the fifth grade, but essentially no differences in first and third grades. Overall, the similarities are more striking than the differences.

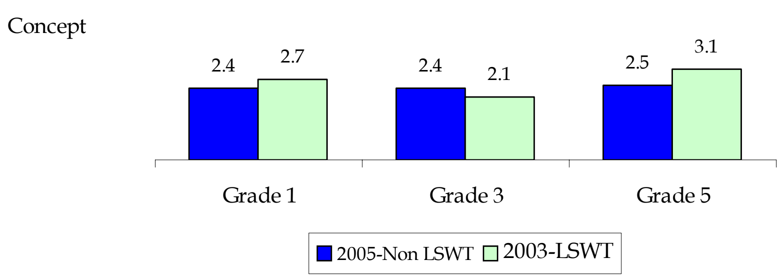
Figure 6.
Comparison of LSWT students notebook ratings in 2003 to non-LSWT students' notebook ratings in 2005

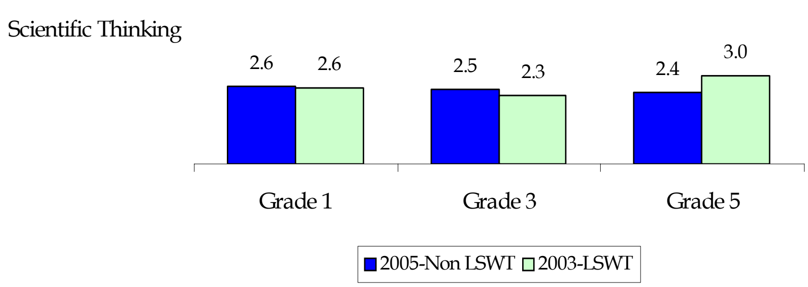


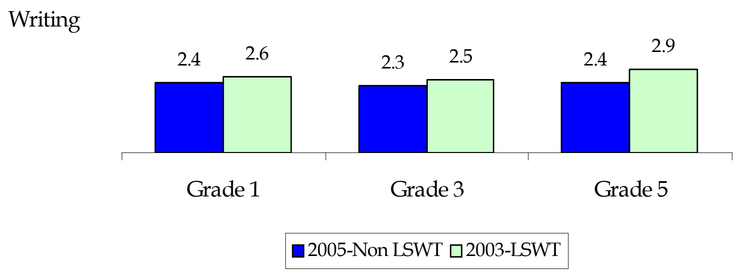
We want to emphasize that we make this comparison purely for exploratory reasons. We did not design the current study for the purpose of comparison (i.e., we did not match school conditions, scoring conditions, or sample sizes, although we did read notebooks produced at the same time of year and used the same criteria) because the current study is serving a different purpose. Nonetheless, it is interesting to see a pattern of student development in the non-LSWT notebooks that looks really quite similar to that of the 2003 notebooks. This result offers some reinforcement for the 2005 LSWT raters' sense that the class sets that they rated at level 3 and 4 for program implementation actually do reflect a degree of program use that approaches their own. The result also reinforces earlier findings by suggesting that the program, when implemented, supports student development in roughly similar ways and to similar extents.

The graphs below compare the ratings of the two different groups by each of the three criteria (conceptual understanding, scientific thinking and inquiry skills, expository writing development). We note that there was slightly more variation across the three criteria for the 2003 LSWT group. Again, given the differences in research conditions, we present this for exploratory purposes only and suggest that the similarities are probably more meaningful than the differences.

Figure 7.
Comparison of 2003 LSWT notebooks to non-LSWT 2005 notebooks on three criteria for student development







Field experts' reviews of student work in notebooks

The perspectives and expectations of field readers

The dozen outside experts reflected a wide range of roles in education. Seven are scientists or science educators working in universities, district-based or independent professional development initiatives, or state curriculum offices. Of these, three are doing research focusing on science learning. Two of the 12 specialize in writing instruction and professional development , including writing in the context of subject matter other than language arts. Two are elementary science teachers. As a group, they brought the following expectations to the notebooks, with different readers emphasizing some more than others:

- That student science notebooks would in some way reflect "authentic work" in science. This meant a number of things. For example, the notebooks would:
    - show evidence of students using the fundamental processes, multiple modes of representation, and language of scientific work;
    - demonstrate students' excitement and personal engagement in the problems or questions investigated;
    - include the range of writing that notebooks of working scientists include;
    - reflect in-depth scientific meaning-making from data rather than accounts of activities for activities' sake;
    - reflect the students' "own" work rather than "black-line masters";
    - reflect the social context of learning and of authentic science;
    - support students asking and investigating questions arising from their inquiries;
    - show students' ability to apply or otherwise connect what they were learning in science to their everyday lives.

- That the work in notebooks would reflect scientific study and writing working together to increase engagement, understanding, and skill in both areas. While these readers were generally more focused on writing serving science (the authentic science purpose named above), some emphasized the benefits to writing development. This included the importance of students' learning the value of "writer-based writing" (e.g., written records of scientific observation to draw from later, as well as exploratory "ideas-in-the-making" serving the writer as inquirer) and also learning the skill of transforming that into "reader-based writing" (e.g.., writing informational text for communicative/publication purposes).

- That the work in notebooks would serve as formative assessment that would help students and teachers gauge learning and guide instruction. Reviewers expected to see evidence of such things as teacher monitoring or students' corrections of misconceptions.

The reviewers also had some questions and doubts about their ability to infer what students were learning because they (rightfully) felt cautious about over-inferring the nature of classroom instruction in science and the role of notebooks in it. For example: How much of the work in notebooks reflected independent/student-directed *vs.* teacher-directed work? The reviewers expected students to have substantial opportunities for independent thought. When were students expressing their learning orally rather than in their notebooks? Most reviewers imagined that the work in the notebooks was only a partial reflection of student experience and understanding.

Reviewers' general impressions of the range of student work

The field reviewers felt they had an opportunity to see a wide range of student work. When they reflected on the general characteristics of those **notebooks that had more of what they felt was important to the teaching and learning of science and writing**, they noted the following:

> The notebooks got fuller as they went on. As students proceeded through lessons, they begin to link them up—to get how things connect in a scientific way. I think writing prompted that by slowing them down.[23]
>
> The notebooks had some space in the beginning for investigative thinking. Formalized writing had a broad range of writing styles—they had a chance to explore early on—and later were writing more to an audience.
>
> The teacher seemed to have such a firm grasp on students and knew when to push and when to pull. Kids felt confident enough sometimes to write 3 pages; sometimes with new concepts there was more guiding.
>
> You can see that the really textured accounts gave the student a better chance to move forward.
>
> Kids are grappling with uptake of scientific language, how to put amplitude onto what they are seeing. Notebooks gave them a formal place to do that.
>
> There was nice linking between the science and writing informational text. There was a table of contents, data charts to review.
>
> There were good attempts to explain—why do things act the way they do?

[23] These are lightly edited quotations and paraphrases from a debriefing interview.

> The teachers and students felt empowered to go back and do an experiment—scientists do this. Made it authentic evidence of real science.

When reflecting on the **notebooks where they saw <u>less</u> of what they believe is important** to the learning of science and writing, they offered these generalizations:

> A few were not that different than a collection of black-line masters. I think real science notebooks are different than that.
>
> Teachers' questions were really simple, so students' responses were really simple. The result is that the students just are answering to get through the lesson—not a good conception of what science is about.
>
> Sometimes there was regression—at the front there was a question and attempt to answer, at the end not much was written. Maybe kids needed other kinds of scaffolding.
>
> There was a confirmatory character to what the kids are after, instead of exploratory. There was less coming back to things to puzzle over. The student is just going along a conceptual story line—exploring is limited. There's very little "Why is it important to do this?"
>
> Little evidence of teacher feedback, and some places where it was under-utilized. Doesn't seem like teachers are using notebooks to evaluate misunderstanding.

Specific features of student work that outside reviewers observed in the full range of notebooks

<u>Students engaged in authentic scientific work</u>. Some reviewers noted that students developed facility with scientific vocabulary, both conceptual and descriptive. One said, "I saw this as a general pattern across." Remarking about the excerpt below from a first grade notebook in which the student was asked to describe the properties of different balls, a reviewer said, "There is evidence that students understand the concept of 'properties' and that they are using all senses to describe them, not just visual":

> *boom boomnoise*[24]
> *pink*
> *sphere*
> *soft*

One reviewer noted that a notebook from the Land and Water investigation [fifth grade] "seems to show quite sophisticated uptake of scientific discourse from beginning to end." Another reviewer said that she was "impressed" with the notebook of a fifth grader whose work exhibited deep engagement in the extended sequence of data gathering and documentation, hands-on experiments with different conditions, and writing for the comparison of three stream tables. She said students "were expected to use numerical data, observational data, and diagrams to make comparisons. The diagrams were colored and labeled, and written observational data could be compared against them." She added, "I think all of this is so important because the student is using many different kinds of scientific processes to compare conditions….is answering

[24] All indented passages in this format are verbatim quotations from student notebooks.

questions, supporting assertions with evidence (such as, *I think this happened because*…). The evidence is data collected during the activity."

Reviewers also noticed that students frequently had opportunities to predict the result of a test based on past investigations and to state whether data confirmed or disconfirmed the prediction. For example, in the following excerpt from a third grader's notebook, a reviewer saw evidence of causal reasoning occurring when data challenged the student's prediction:

> *How does sound travel?*
> *I predict the sound will travel best through the yard stick.*
>
> *I listened and noticed the <u>foil strip</u> was the loudest. Therefore, I think sound travels best through <u>metal.</u>*

Commenting on a fifth grader's investigation of how hills affect the flow of streams, one reviewer said that the "student demonstrates a sense of self as a good observer and participant in scientific investigation, a sense born out of the work that precedes this page." For this lesson, the student had written:

> *I predict the large hill will get water on it and at the end I think the hill will give way because the water will pile until it has enough power.*

Then, following several entries devoted to specifying the "manipulated" and "controlled" variables, the materials needed for the experiment, and a drawing of the resulting stream movement in relation to the hill, the student wrote:

> *This data does not support my prediction because I observed that instead of hacing the water make the hill give way it went right around the hill and the hill didn't get very wet.*
>
> *In conclution I think that a hill does effect the flow of the stream.*

As much as the field experts were often pleased to see the scaffolding that guided students' thinking (e.g., carefully worded questions, attention to transition words), they were especially impressed whenever they read entries that seemed to stem entirely from the students' own sense of what was important. For example, a field reader called the following excerpt "awesome, honest writing. The student didn't get what they expected, but understands the nature of science. You still need to write about what you discovered":

> *[Vocal cord experiment] When I blew into the thiner for the first time I got nothing then I blew again I got a low pitch, so I figured that I wanted to write about it because it could be important.*

Some reviewers looked for evidence that students were experiencing learning in a social setting. One pointed to the following example as evidence that students were learning to investigate questions by doing their own experiments and also seeing how other student scientists approach the question.

How can we make sounds with string?

I used fishing line attached to a washer so the fishing line could be attached to the cup, [___] who is my partner and I made vibrations by giving the washer slack. Then pulling the fishing line up really fast whoever was holding the fishing line would feel the vibrations. Some other kids like [___] and [___] made the pitch change by plucking the fishing line with finger and made the fishing line longer and shorter.

Another reviewer remarked that the following excerpt from a first grade notebook showed "evidence that science is a social endeavor in the classroom":

I noticed that wane me and my portnr kocte summing over the pip pog Ball kocte it dowe and the robr Ball Joct movd the tiyoL because the robr Ball insid than is robr in the robr Ball. Also wane me and my portnr bib [did] wich Ball rolls fastr the pip pog Bal rold fastr because the pipog Ball is Hollow.

While reviewers found several occasions when students made connections to their prior knowledge or daily lives, they remarked that on the whole there was less of that than they expected. After reading several 5th graders' notebooks from the Land and Water unit, for example, one reviewer found only these two statements about water that bespoke any personal connection:

I know that you have to have water to take a bath or shower.

You can swim in it.

The following are excerpts that outside reviewers pointed to as examples of students making important connections between specific lessons and broader understanding. Below, a third grader who had been studying sound had the opportunity to apply knowledge about vibrations to explain how eardrums work:

What can we do to show that sound causes vibrations? [focus question at top of page]

[This is followed by a drawing illustrating the set-up for the experiment. Everything is labeled. It shows a cup, covered by latex secured by a rubber band. There is tea drawn on top of the latex and just above the tea is a drawing of a noisemaker.]

What we did was we put Latex onto a cup. We put tea onto the Latex. What we did to make the Latex move was we put a noisemaker over the tea so that made the tea move. This is something that is like an eardrum because when we put the noisemaker over it it will vibrate. When we hear sounds our eardrum vibrates.

A reviewer noted that the following, in a fifth grader's notebook, showed good qualitative description that made a connection between a model and an investigation, and an additional link to prior knowledge:

Focus Question
What happens to land as it rains and where does the rain go?

Prediction: I think the rain will make small rivers and streams in the land. I also think the water will make dents in the land where it hits. Finally, I think the water will either be soaked up by the land or run off out of the hole.

Observations:

As it rained I noticed that the top of my land was rippled with dents but mostly stayed the same. Next, I noticed tha the bottom of my land had no dents because it had completely slid down.

I think the rain got soaked up by the land because at first no water appeared after it had been sprinkled on the land but when more water had been sprinkled the water poured into the bucket looking looking brown.

This remids me of an avelanch because more and more snow builds up then falls.

As positive as they were about much of what they saw, several reviewers observed a perfunctory or formulaic quality in some of the notebooks. One person said, for example, "Some teachers provide a lot of structure in what the children record, while others seem to give the students more leeway to put their own thoughts down. [In three of six notebooks] I felt they were just filling in the blanks. Not much independent thought." Another person said that in some classrooms, "when there was a question related to conceptual theorizing there seemed to be a fair amount of parroting" or "pat answers" rather than "personal constructions." This reviewer went on to say the following about the contrast between the six notebooks that he read (two at each of three grade levels) and the notebooks of working scientists:

> These [student notebooks] are more like cleaned-up accounts of inquiry than wrestling with the ambiguities of actual inquiry. The notebooks seem selective and summative, not comprehensive and free-ranging. They seem more like scientific publications than scientific notebooks. Scientists' notebooks are full of data and also full of probings of ambiguities and anomalies. This is distinct from writing about science for an audience, or publishing one's ideas in well-explained form, citing data. The latter is also important for students to learn but it is often distinct from 'notebook' for scientists, and so maybe that distinction would be helpful for students. These notebooks emphasize collection of data moving to clear explanation without the 'struggle.'

Below are two excerpts from first-graders' notebooks, in which they have predicted that a ball will roll farther down a ramp that is higher. The reviewer suggested that, even though the prediction was probably in the right direction, the "reasoning is a surface description, not a conceptual cause":

The cup would move 29 am because it has mor blk [blocks]

The cup would move 60 cm. because it is ou higher

And in the following notebook, a reviewer commented that a third grader answered the quite simple questions without addressing the conceptual "why":

Slide whistle
What makes a whistle work?
You need air
What do you have to do to change the pitch?
You push and pull the wood in and out.

Citing the following example, one reviewer said that "the notebook is set up as lessons—students seem to be answering teachers' questions, not thinking with their writing" nor "prompted to say why":

> *Lesson 10*
>
> *How do you think the hay infusion has changed over the last 3-4 weeks?*
>
> *I think it's gotten browner, smelly, and sogy.*
>
> *How do you know if something is alive?*
>
> *You know it's alive because it grows, breaths, changes, needs food, and needs water, produce waste, have cells.*

On the whole, although the reviewers noted a pattern of over-structured student responses, they also found that many notebooks showed strong evidence of authentic work and thinking in science.

<u>Writing and science serving one another and developing together</u>. Reviewers expected the work in the science notebooks to reflect writing in the service of learning and "doing" science, and science as a context for developing written communication skills.

Several reviewers commented that well-phrased questions often helped guide the students' conceptual development. One noted, for example, that the question below is more helpful for students learning about sound than the more general (and typical) question "what have you learned":

> *What have I learned so far that will help me design a read [reed] instrument?*

Several reviewers commented that students' use of a variety of data-gathering and portrayal techniques (drawings, diagrams, graphs, matrices) seemed to enhance mutually the writing and the conceptual development in science. About the excerpt below, a reviewer observed that the combination of a "sophisticated cut-away view of a straw," together with the written explanation, showed "advancement of cognitive development":

> *How does the length of the vibrating air column affect pitch?*
>
> *[This is followed by a cut-away side view illustration of a straw with three holes in it. The reed, holes, straw, and the path of the air are labeled.]*
>
> *My straw was short and had a high pitch when I didn't cover any holes and made a meadium/high pitch when I covered the first hold and on the middle and last hole mad a medium/low pitch. My straw vibrated very fast when I didn't cover any holes*

One reviewer remarked that the following excerpt from a first grade notebook was "one heck of a great example" of scientific understanding and expository writing evolving hand in hand:

> *F.Q. Wich balls were the best bouncers?*

> *We tested the "bounciness" of balls by using a ruller, and one of us droping the ball the othr prson measurd how hi it bounced in inchs, we also countd how meany inchs it bounced.*
> *The "bounciest" balls were the pink rubber ball, the tennis ball, the sm. Polsture [polystyrene], the sm. glass ball, and the ping pong ball.*
> *The least bouncy bll were the sm. wooden, the lg wiffle, and the lg polysture. The propties that good bouncer share are the size small, and big and texter fuzzy, and smooth. The best bouncers were made of rubber, fuz, styrofoam, gass, and plastic. Wood dos not make a good bouncer.*

A number of reviewers pointed out that the scientific work of conducting investigations served as a kind of pre-writing that students could draw from to create well-developed (data rich) and organized explanations for other audiences. Several reviewers also observed that students had many opportunities to build their skills in the use of appropriate transition words (*because, therefore, also*, and so on) linked purposefully to the processes of observing and explaining.

Along with the positive evidence of writing development and the reciprocal growth of writing and science that they saw in the notebooks, the reviewers expressed two concerns about writing opportunity, both echoes of concerns expressed in the previous section. While recognizing that the effective use of scaffolds is a fine art, the reviewers cautioned against over-use of (and students' over-reliance on) "given" transition words. Additionally, reviewers expected to see more opportunities for students to write in a more exploratory, less pre-structured fashion. Fundamentally, the reviewers strongly valued the use of notebooks to record scientific processes and data through writing as well as the use of notebooks to craft well organized explanations of scientific information; what was lacking was the writing-as-thinking (the "struggle" described above that appears in scientists' notebooks) that often occurs *in between* the data collection and the well-crafted explanation.

Notebooks used for formative assessment. The reviewers recognized that the notebooks alone gave them limited information about the use of notebooks for formative assessment. That said, they were a bit surprised by the number of times they observed that students' misconceptions seemed to persist through several lessons. They deduced that teachers were not often monitoring students' work and providing feedback that would cause students to reconsider their data and conclusions. Some reviewers also noted that teachers seemed perhaps too satisfied with responses that seemed merely descriptive when they might have pushed for more "student thinking" or "causal conjecture."

In the following, for example, the reviewer doubted that the student understood the relationship between length of object, vibration, and pitch. The notebook did not contain evidence of ongoing work toward greater accuracy of vocabulary or clarity.

> *What I have learned so far*
> *I learned that the most sound came from the little tunning forks. We used nails, rulers, and tunning forks. The short sound came with the long tunning fork. Yesterday we did an*

experiment with rulers we did it with leng-h-t we did it with. Three numbers 28, 15, 5 the most sound got number 5.

[This is followed by a drawing of a ruler on a desk; the end of the ruler farthest from the desk has a 5 on it followed by a 15 and a 28 close to the desk.]

Similarly, another reviewer noted that the following student was struggling with the pitch-length relationship, and wished there were some intervention.

Pan pipes the bigger the tube the highr the pitch, the smaller the tube the higher the pitch.

Some notebooks, though, showed evidence of teacher monitoring and feedback. A reviewer observed that in the following, a teacher prompted a student to provide more development in writing:

3/24/05
What happens when we remove some vegetation? Prediction: There would be more groundwater. Manipulated variable: removing grass

3/25/05
There was more groundwater. There was more dirt in the bucket. And there was more erosion when the land moved. My prediction was right.

Teacher: [name], you have such great ideas when we have class discussions! I would like to see more written in your notebook. There is a lot of incomplete work here.

In summary, while the field experts saw room for students to be pushed toward more independent thinking and expression, what they observed in the notebooks persuaded them that students are benefiting substantially from the opportunities to use notebooks regularly as a context for learning in both writing and science.

D. Does partial or low-fidelity implementation provide benefits to students without producing detrimental effects?

This is the "apple or pork chop" question: To what extent does a low level of implementation produce partial benefits that make it better than no implementation (half-baked apple)? Or is there a risk of detrimental effect from low-level implementation that outweighs the benefit (half-baked pork chop)? We asked this directly of both the LSWTs and the outside experts after they reviewed the full range of student notebooks.

Finding	Overall, most notebook reviewers deemed even minimal use of science notebooks as more of a benefit than a detriment. Reviewers in both groups assumed teachers could develop better skill in using notebooks. Most LSWTs have a concern that students' habits developed in classrooms with the very lowest levels of implementation will require an extra investment in "un-teaching." Field experts were more inclined than LSWTs to say that, even in the thinnest of notebooks, benefits outweigh detriments.

The field experts were quite strongly inclined to see the work in even the "thinnest" of notebooks as better than no use of notebooks at all. Only one person suggested that if students are not given enough diversity of ways to respond, they could become discouraged and this may be detrimental. One reviewer said that because writing is so time-consuming and labor-intensive, teachers have to think about whether there are other things students can do that are more productive. This person and the others agreed that even a few opportunities to develop data charts and answer questions in writing was, on the whole, more productive than not having such opportunities. One reader noted that merely copying the teachers' focus questions could have benefit for some students: "I had one notebook with only guiding questions—no answers…For special ed kids it is a lot of work—but it helps them see where the investigation is going." Several reviewers noted that even when not richly and fully used, the notebook can give the students a context for processing learning and can create a way for teachers to intervene. Others noted that if students have multiple opportunities to work in notebooks even minimally, "they'll get it after a few years." They noted too that "teachers have to start somewhere" and can learn to help students use notebooks more productively if they receive professional development support.

Overall, LSWTs were slightly more inclined than the field experts to see minimal implementation as a potential problem (i.e., a "half-baked pork chop") rather than as a limited benefit. The LSWTs were mixed in their views, depending upon whether they tended to see class sets rated at level 1 or 2 as "something to build on" or "something to un-teach." Most LSWTs considered the notebooks in class sets they rated at level 1 to be more of a problem than a benefit because students would develop poor ideas about the use and role of notebooks that future teachers would have to un-teach; however, a few noted that even poorly used notebooks at least gave students a "place to think." LSWTs were quite mixed in their assessment of the benefits to students for class sets they rated at level 2, where both the science and the writing were inconsistent. For example, a couple of teachers thought that having students fill in charts with observational data in a rote and scripted manner (all charts exactly the same, showing lack of individual learning and data documentation) was more of a problem than a benefit because the students would be filling out charts but not understanding why and thus were not "learning." Most teachers, though, thought that at least these students would get some familiarity with chart structure and that was of more benefit than not doing it at all.

III. REFLECTIONS AND IMPLICATIONS

Elementary school teachers must make choices within an environment that asks them to connect multiple curricula with learners with diverse and individual needs, to take into account local community values, to juggle multiple and changing policy directives, to suit all of this activity to the particular culture and demands of their school workplace, and to accomplish this within the constrained resource of time for instruction, individual professional development, and participation in school improvement. We take this reality of teaching into account as we reflect on what we learned and on implications for the program's development and its benefits to students and teachers.

Four ideas stand out from the quite massive amount of data and findings that this study generated.

1. The model for teaching writing in science that the Expository Writing and Science Notebooks program espouses appears to be fundamentally sound in its ability to support student learning in both science and writing.

Findings from this study reinforce what we have learned from earlier studies about the value and benefits of this approach to using notebooks to support the teaching of writing with science. When the program is implemented reasonably fully, students have valuable opportunities for learning and for communicating what they have learned. Even when implemented at a minimal level, the great majority of reviewers believe there are clearly more benefits to students than detriments.

2. Given the realities of teaching elementary science, it is impressive that there is a degree of observable and productive implementation of the Expository Writing and Science Notebooks program by teachers who have taken a modest number of writing classes spread out over several years.

The contextual conditions that favor high quality teaching of science at all—much less the implementation of the Expository Writing and Science Notebooks program's approaches within science—remain very weak compared to the conditions that inhibit the teaching of science and full use of notebooks. Thus, the impetus for implementation of the science program with notebooks currently resides in individual teacher commitment.

Further, with only a couple of exceptions, these teachers' knowledge and confidence related to teaching science and also writing are quite minimal compared to their confidence in teaching reading, mathematics, and social studies. That is, on their own, most teachers would not be able to act productively upon their personal commitment to teach science. Rather, they rely upon the district's science curriculum and professional development for the knowledge and skills they need. The district's Expository Writing and Science Notebooks program provides teachers with a model to follow (in the form of the supplemental curriculum and guidance as to teaching strategies) and enough workshop-style professional development to enable them to at least give the program a try as part of their science teaching. In nearly half the cases within our sample, teachers were able to implement it well enough that students are benefiting in ways that are congruent with program goals.

3. Indications are that a greater proportion of committed teachers could achieve stronger implementation within the same context conditions if the Expository Writing and Science Notebooks program took two related steps in the future: To streamline the model and its attendant materials, and to offer developmental support for teachers as they work to master the teaching of science and this model for writing in science.

Eight of the eighteen class sets were rated at level 2 for implementation, meaning there was evidence of a real attempt but that fell short of consistency. This tells us that what some teachers need is probably not greater personal commitment but greater capacity to implement productively in the face of inhibiting pressures. The LSWTs also commented that a good number of teachers just seemed to need to learn more about how to make the writing work better for students.

There is a maxim about implementation that we at Inverness Research have seen hold true across studies of curriculum-based initiatives of different types and scales. While higher fidelity can increase the positive outcomes of an approach, a rigorous standard for fidelity when combined with significant complexity reduces implementation. That is, proportionally fewer people are able to implement a more complex approach when high fidelity is the standard. Conversely, lower complexity and fidelity can substantially increase implementation. The trick, of course, is to find a level of complexity and a degree of implementation that produces significant benefits for teachers and students while remaining feasible given context conditions.

Based upon what the teachers in the sample told us about the science writing program, and based upon the maxim we discuss above, we think two kinds of opportunities would help teachers strengthen their implementation and thus enhance significantly the benefits to students.

First, the teachers in this study generally found the writing packets, and the multiple versions of them, to be overly complex and full. The teachers are sometimes confused about whether they have the current version, and they do not find the time to pore through different versions to identify changes.[25] What may seem like a major update to the program leaders can seem like a subtlety to the typical science teacher, and what may be intended as a greater wealth of examples can seem like an impenetrable mass to the teacher—who may have asked for more examples, but in fact cannot find the time to pore over them fruitfully on her own. Some teachers also mentioned that they can get confused because there are packets for the science unit, packets for the notebook writing, and sometimes other resources, and they have difficulty sorting it all out on their own. We have noted in past studies that the science writing program is quite likely to be feasible for implementation because it is well specified, i.e., has a curriculum strand with professional development attached. We caution, however, that the cumulative effect of

[25] Recall that program leaders revised the materials to align them with state standards and assessments that were formulated after the science writing program was established.

program refinement could inadvertently make the program overly complex, even overly specified. While it seems paradoxical, we suggest that streamlining the model and its attendant teacher materials might make it more feasible for fuller implementation.

Even as we propose this, we want to suggest that fuller implementation does not rely solely on the packets (i.e., curriculum resource). Rather, we believe it rests equally on opportunities for teachers to receive ongoing support as they try out the model (i.e., curriculum plus professional development). Both the teachers in the sample and the LSWTs see teachers' mastery of the science units and the writing program as developmental, requiring a building up of both skill and judgment over time. Just as the LSWTs have benefited from talking through the details of planning how the writing would fit into and enhance the science unit, we believe teachers wanting to implement the program would benefit from joint planning—specific to units—for how to implement the writing strategies. And just as LSWTs have benefited from discussing the work in student notebooks together, we believe other teachers would benefit from studying student work together—at their grade levels and for the units they are teaching. We assume there are many possible models for how to do this and further assume that, given differences among teachers and their contexts, multiple localized approaches may be necessary. We assume further that these opportunities do not replace the series of writing classes, which serve as the very strong common foundation, but build from them.

We envision the streamlining and developmental (even differentiated) approach to teacher support as working hand in hand. In terms of the supplemental writing curriculum, for example, there may be some lessons or sequences (customized for units) that create more fruitful writing opportunities than others and that teachers should not miss even if they feel they cannot devote the time to the comprehensive writing strand. In the context of group support for planning, teachers might think through how to make trade-offs on some activities that make great demands on students' time and physical abilities but have smaller payoffs in terms of learning. For example, reviewers noted that students often had appeared to spend a great deal of time drawing matrices for data and recording many trials in individual notebooks (sometimes group trials with exactly the same data), but wrote one-sentence responses (or no responses) to focus questions that asked what they were thinking and learning. We note, by the way, that the LSWTs who rated class sets for implementation showed strong fidelity to the program, as we relied on them to do; at the same time, they exhibited great discernment of different qualities of implementation and degrees of student benefit. We are confident that they could contribute from their daily classroom experience and good judgment to the streamlining steps that we suggest. For example, they could collectively decide, and recommend to other teachers, places in some units where data collection might be recorded as a group rather than individually so that the bulk of "writing" time be used for recording thinking. We are mindful of the little time the average teacher can devote to the use of notebooks.

As outside observers, we can offer no more specific suggestions. Rather, we only suggest that too-great complexity can undermine the very teacher confidence that this program relies on for any implementation at all.

Finally, a comment about teachers studying student notebooks together: In our earlier studies, LSWTs told us they benefited greatly from reading whole student notebooks from start to finish. Teachers gain more insight into students' learning opportunities and gains by observing their work over time, and teachers learn more when they discuss the work together. Similarly this year, LSWTs told us they benefited from reading a set of notebooks from a classroom; one learns a great deal about *teaching* from this exercise. In fact, several LSWTs told us that they would take this experience back to their own rooms and "boost" their own implementation of the program. By reflecting on other teachers' notebooks, they could recognize both gaps and strengths in their own teaching.

4. We suspect that a significantly broader degree of teacher commitment leading to implementation depends upon the extent to which science achieves higher priority at the school-site level. The higher school priority would bring science into sharper focus for individual teachers and make science a legitimate subject of teachers' joint work at their school sites.

Recall that when we created the sample for this study we found 64 teachers at three grade levels who had taken 4.5 or more hours of writing classes in recent years but who are not LSWTs. Of them, about 1/3 said they were teaching science and using at least some of the writing strategies. Given the vagaries of scheduling that disrupt teachers (having an intern or team teacher doing science, etc.), a generous assumption is that about half the teachers taking three or more classes are using the science writing model. Based on what we have learned from this study, our inference is that at least some of these teachers' personal commitment to teaching science and to teaching writing within science is not strong enough to outweigh the low priority of science (and perhaps writing) in their schools and the time pressure against it. (If it is because they think the program is too complex or the classes not adequate to implementation, the suggestions above may help.) And while teachers said that school conditions are a weak influence for science, they implied that school conditions have been a strong influence for reading and math, which *every teacher* named as the top priorities. Stimulating schools to embrace science is certainly a long-term effort but it seems necessary to broadening implementation substantially beyond the current level.

APPENDICES

1. The Pedagogical Approach of the Expository Writing and Science Notebooks Program

2. Rating Sheet for Class Samples

3. Rating Sheet for Individual Notebooks

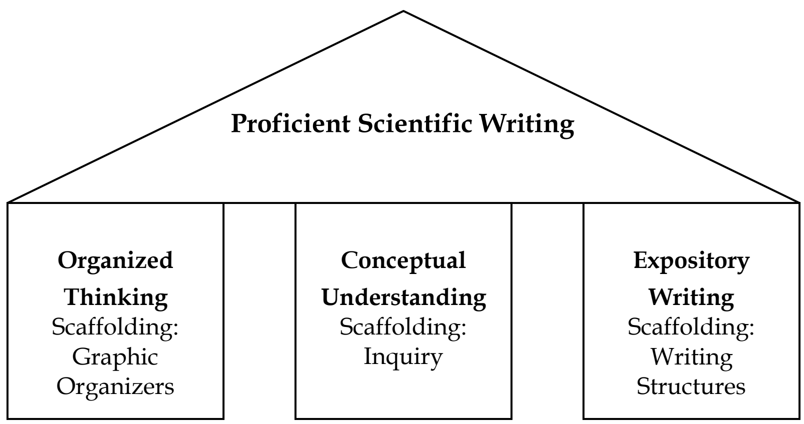
4. Teacher Interview Protocol

APPENDIX 1

The Pedagogical Approach of the Expository Writing and Science Notebooks Program

By Betsy Rupp Fulwiler
Program Developer and Coordinator

The pedagogical approach described in the *Expository Writing and Science Notebooks Program* is based on the rationale that elementary students need structured support in three areas in order to write proficiently about science.



First, students need to construct understanding of science concepts through engaging in guided and open inquiry. To help scaffold the inquiry, each lesson in a unit of study has a focus question, which is derived from the conceptual story of the unit and serves as a means of focusing the students' thinking as they engage in their investigations. These questions often, but not always, are the investigative question of an experiment (e.g., "How does water flow affect erosion and deposition?" "Does wheel size affect the distance a go-cart can travel?").

As students are developing their conceptual understanding—as well as their scientific skills and thinking—they need graphic organizers and word banks to organize their thinking, to help them remember what they are learning, and to lead them to deeper levels of understanding as they construct and explain their own organizers (e.g., scientific illustrations, diagrams, T-charts, tables, graphs, flow maps).

Finally, as they begin to write expository text to communicate about their scientific understanding, they need writing structures or frames to help them remember what they need to describe and explain as well as to support them in learning how to write scientifically, with clarity, accuracy, strong details, and organization.

These three components—conceptual understanding, organized thinking, and expository writing—are developed through ongoing modeling by the teacher, practice, and constructive formative feedback.

To promote the quality of thinking that the approach advocates and to maximize the amount of energy elementary students have for writing and the amount of class time teachers will devote to the teaching of science, students focus their writing energy on entries that will help develop their conceptual understanding and/or scientific skills and thinking. Thus, they write in detail about their observations, data analysis, and conclusions, but only occasionally, in specific instances, about procedures, because that type of writing involves lower level thinking and writing skills.

As students progress through a unit of study, they write in their science notebooks during and/or after <u>every</u> science session. To ensure that the writing does not detract from the science learning and the science learning does not diminish the writing development, teachers teach higher-level writing skills in separate 20- to 30-minute minilessons outside the designated science class. For each of their science units, teachers who attend writing classes in the program are given a supplementary writing curriculum that provides suggestions for writing in each lesson. These suggestions are based on the conceptual flow of the unit, and introduce different graphic organizers and writing structures that best support the students' needs at that point in the unit. For example, as students begin a life science unit, they might follow an organizer for guiding their observations as they observe an organism. During a minilesson outside the science session, the teacher might model how to draw a scientific illustration of one organism and involve the students in a shared writing of a description of that organism (i.e., students provide the content of the description while the teacher models the structure of the writing). After students observe and draw a second organism, the teacher might model a compare-and-contrast strategy using a graphic organizer and a writing frame. Students would then use the strategy and frame to write their own comparisons. Later, the teacher might model and involve students in analyzing and writing about the qualitative and quantitative data they have collected about their investigation of pollution and its effect on the organisms. Finally, the teacher might model how to write a conclusion using a graphic organizer and/or a writing frame before students would write their own conclusions independently.

Through the modeling, shared writing, and guided or independent practice, students learn how to write analytically about their conceptual understanding and scientific skills, and through the process, deepen the understanding and critical thinking skills they have been developing through their scientific investigations. This approach thus represents a meaningful integration of the content domain of inquiry-based science and the skills-based domain of expository writing. This kind of synergy can result in high levels of student achievement in both science and expository writing.

APPENDIX 2

ELEMENTARY SCIENCE NOTEBOOKS STUDY
LSWT Reading Day—May 25, 2005

RATING SHEET FOR CLASS SAMPLE
Evidence of implementation of *Expository Writing and Science Notebooks Program* within context of science unit

Class sample ID *(first three numbers/letters of notebook codes)* _________________

Rating of this class sample *(1-4)* _______________

1	2	3	4
Virtually no evidence of program implementation	Evidence of use of some strategies but with minimal purposefulness	Clear evidence of use of strategies, but with inconsistency	Evidence of quite thorough and purposeful implementation of key program elements.

Types of evidence seen and reasons for the rating:

APPENDIX 3

ELEMENTARY SCIENCE NOTEBOOKS STUDY
LSWT Reading Day—May 25, 2005

RATING SHEET FOR INDIVIDUAL NOTEBOOKS
Evidence of student learning

ID code *(full sequence of numbers and letters)* ________________________

Ratings for this notebook:

Concept	Scientific thinking	Expos Writing	Total

Rating guide

	1 LIMITED	**2 DEVELOPING**	**3 ADEQUATE**	**4 FULL**
KEY SCIENCE CONCEPTS OF UNIT	Quite limited understanding	Partial understanding	"Pretty close" understanding	Accurate and quite full grasp of the major concepts
SCIENTIFIC THINKING AND INQUIRY SKILLS	Random "bits" of activity lacking apparent purpose	Use of some skills, but often lacking thoroughness or purpose	Many skills used accurately, with minor inconsistencies	Thorough and purposeful use of skills to advance learning
EXPOSITORY WRITING	Content/idea unclear	Idea/content incomplete in development; inaccuracies in logic and technical vocabulary.	Communicates adequately but has some inconsistencies in clarity, development, organization/logic, or technical vocabulary	Content/idea is clear and fully developed, with appropriate organization/logic and accurate use of technical vocabulary

Are there one or two lessons that best reflect the ratings? If so, please identify them by the date of the lesson and make a brief comment:

Date Comment

Date Comment

- Use back if necessary –

APPENDIX 4

Seattle Teacher Interview Protocol
Science Notebook Study
May 2005

Intro. Thank teachers for being willing to share their students' notebooks and talk with us. Assure them that their anonymity is ensured and that we carefully covered all names in the notebooks to guard student anonymity.

Our purposes for this interview: One is to find how teachers teach science and writing in science, including their beliefs about the value of writing in teaching science. We want to find out what influences, in addition to the writing classes, have been important or key in their decisions to have students write in science. A second is that we want to find out what professional development a teacher has had in writing and science, its influence in her/his teaching, and if s/he would want to have more. A third is to learn about the students in the samples classes generally and to clarify the designations of the students whose notebooks we sampled. Assure the teachers that the designations are coded and are only for the researchers' use.

I. Teacher Background

- Number of years teaching
- Years at grade level
- Years at this school
- Years at this grade level at this school

- What subject area(s) are you most comfortable/confident teaching? How comfortable/confident are you teaching science?

- How much professional development have you had in science writing? In science? In writing other than in science? Other? How has this shaped the way you teach science?

II. Teaching Science in your classroom

- How many students do you have in your class? Describe your students so I have a sense of who they are and what it is like for you to teach them.

- What does your science program look like? How many units do you teach? What are they? How do you teach them – partially, completely, in order, pick and choose? Do you add lessons from sources other than the district-provided kits? How much time do you generally spend on science weekly? How much total time on teaching a unit?

- What is the priority of science teaching at your school? How does it compare to language arts, math, and social studies in terms of time that should be devoted to it? Do you think the school's priority is about right? If not, would you teach it more or less than it is currently supposed to be taught? How well does your own teaching of science match your school's priorities? (Do you teach science more, about the same, or less than most of the other teachers in your school?)

III. Teaching writing in science

- Tell me how science notebooks and writing in science fit into your science units.
    - How often do you use science notebooks in teaching science? How does that compare to previous years? How does that compare with other teachers in your school?
    - Where in the science lesson do you generally have students write? Why there? What sorts of tasks do you give them? What sorts of feedback do you give them? What percentage of your lessons would you estimate that you use prompts provided the Expository Writing and Science Notebook classes?
- What are your purposes for writing in science? How would you describe the value and benefits for student learning? To what extent do these benefits apply to all students? What about ELLs, special needs, high achievers: Are the benefits the same or different? What accommodations do you make for different students, if any?

IV. Value of writing in science and Expository Writing and Science Notebooks professional development

- How many science writing classes have you taken? In what ways, if any, have the science writing classes affected your approach to teaching science? Other subject areas?
- Have you had other professional development that has influenced your approach to teaching writing in science? If so, what was it?
- What kinds of supports would help you move to the next level in your teaching of science and science writing? Would you take more professional development in writing in science if new classes were offered?

V. Summary of Factors that Influence Teaching Writing in Science

I'm going to list a number of factors that might influence your teaching of writing in science and use of notebooks, and ask you to rate them for me. For each, I'll ask you to tell me how strong an influence that factor is on your teaching of science on a scale of 1-5, and then ask whether this factor increases or decreases how you use of writing in notebooks for teaching science. *(Attach this rating sheet to teacher info sheet)*

	1= No influence				5= Extremely strong influence	Decreases use of notebooks for writing in science	Increases use of notebooks for writing in science
own overall level of knowledge and skill in teaching writing in science	1	2	3	4	5	____	____
own overall confidence in teaching science	1	2	3	4	5	____	____
own beliefs about the value of writing in science	1	2	3	4	5	____	____
amount of PD in science writing and/or science	1	2	3	4	5	____	____
quality of PD in science writing	1	2	3	4	5	____	____
availability of up-to-date writing packets for the units I teach	1	2	3	4	5	____	____
degree of fit/appropriateness of district's writing packets with the science units	1	2	3	4	5	____	____
own level of agreement with the appropriateness of the writing strategies promoted in district classes	1	2	3	4	5	____	____
help from school colleagues	1	2	3	4	5	____	____
amount of time available for teaching science	1	2	3	4	5	____	____
students' skill level	1	2	3	4	5	____	____
priority of science at my school	1	2	3	4	5	____	____
emphasis given to science writing at my school	1	2	3	4	5	____	____
district expectations for science learning	1	2	3	4	5	____	____
standardized test demands (e.g. WASL)	1	2	3	4	5	____	____
Other?	1	2	3	4	5	____	____
Other?	1	2	3	4	5	____	____