Writing in Science

in Action

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Strategies, Tools, and Classroom Video

Betsy Rupp Fulwiler

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In memory of Lynn Barnicle

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Foreword

The use of science notebooks in science teaching and learning has, over the past decade, become almost a fad. There are many different kinds of notebooks you can buy in quantity to use with students. There are many books available on how to include science notebooks in the classroom. There is even a new word that has crept into the jargon—*notebooking*. But few if any of the people who talk and write about notebooks bring to their work the depth of experience, expertise, and thought that Betsy Rupp Fulwiler does. I am a regular user of her book *Writing in Science*, published in 2007. I assign it to my preservice students, I give it out in teacher development workshops and courses, and I recommend it to many others. It was therefore with great anticipation and delight that I looked forward to *Writing in Science in Action*. I was, of course, not disappointed. Once again, she has provided us with a rich resource for deepening our understanding of students' writing in science and a wealth of ideas and practices for use in the classroom. And this time it is not just a book but also a series of wonderful classroom videos and a website.

There are many reasons to explain why Fulwiler's work is so important and received so well. This is not the place to list them all. But I have several favorites. Perhaps foremost among them is the fact that Fulwiler is a rare literacy expert who has spent years to truly understand the nature of inquiry-based science. Her work is not about practicing writing in science, too often the view of the literacy world; it is about the importance of writing for science learning. At every turn she insists on the primacy of experience and the role writing plays in drawing meaning from that experience. This is not about simply connecting science and literacy programs; it is about the authentic use of writing in science learning as the important tool it is.

Another favorite reason is Fulwiler's deep understanding and respect for the work teachers do. What she writes about is an approach and practices that have been honed in the classroom by real teachers with real children. You feel their presence throughout and see them in the videos. Fulwiler also acknowledges the time it takes to learn to do something new—three years for inquiry science and the writing. This is not a quick fix or new gimmick—it is not a scripted curriculum. Rather, Fulwiler's science-writing approach is a deep and powerful way to teach children.

And a third favorite reason I value Fulwiler's work so highly is her insistence on the practical and useful. This book grows out of the questions, needs, and requests of the teachers with whom she worked. Her first book presented the approach and its foundations in detail before moving into practice. This book is mainly about classroom practice. In it she has responded to teachers who tell us over and over again that the most powerful help comes in the form of classroom examples and the experiences of practicing teachers. For each of the instructional strategies she highlights, she uses carefully interconnected video segments, student work, detailed classroom vignettes, and a website to illustrate and to take the reader into the richness and complexity of individual classrooms and the practices of skilled teachers.

I was particularly delighted with the descriptions of suggestions for interacting with children. Fulwiler not only shares the work of individual students but she also suggests how one might interact with that student around the work. This is unusual and very welcome. Too often teachers are given a first step—"have students write about. . . ." or "talk with students about. . . ."—with no guidance and support for what to do next. We are told what to say and do but not how to take the next step and respond to children.

I want to mention one more gift in this book that I value enormously. Part 2 is on assessment. It is now many years since research findings began to suggest that unless teachers assess and respond to students' notebooks, the impact of their use is minimal. But, of course, not just any kind of assessment has the power to enhance learning. In *Writing in Science*, Fulwiler provided a chapter to set the stage. In this book, a whole section provides extensive guidance on how to assess notebooks in multiple ways so that teachers and students are part of the process and learn from their work.

I look forward to dipping into this book, the video segments, and the website over and over. It will be a wonderful resource for me and those with whom I work. And, as Fulwiler herself says, it is not a book about a static approach. It is a book that starts the creative and interested teacher down a pathway with clear guidance and structures but also encourages teachers, particularly those working together, to go beyond and make this work their own.

Karen Worth
Wheelock College

Acknowledgments

I began developing what became this science-writing approach almost fifteen years ago. In *Writing in Science*, I acknowledged the many organizations and individuals who helped to support and develop the work. Since that book was published in 2007, other individuals and organizations have provided additional support to further develop the project, building on what the first supporters had done.

First, I want to thank the National Science Foundation (NSF), which has funded the last five years of this work as we developed the materials to help educators across the country implement the *Writing in Science* approach. I particularly want to thank our program officer, Bob Gibbs, for his guidance, support, and visit to classrooms, where the students were thrilled that he had come to see them working as scientists.

I also am grateful to the Nesholm Family Foundation, which, through the years, has provided funding for the Expository Writing and Science Notebooks Program in Seattle Public Schools. This program has enabled us to provide professional development for the district's teachers, which, in turn, has informed our work with teachers elsewhere. We are honored to assist them in their mission of helping underachieving students reach their full potential.

I am especially thankful to have worked for the last fifteen years with Elaine Woo, the program manager of the PreK–12 Science Program in Seattle Public Schools. Elaine is a remarkable visionary who also has incredible skills in turning ideas into real programs that positively impact all students. Due to her tireless efforts and leadership, we have been able to continuously develop our elementary science and science-writing programs for more than a decade, thereby allowing the district's teachers to benefit from high-quality professional development and their students to learn science through inquiry throughout the school year.

The science team and the district's teachers could not accomplish their work without Penny Knutzen's intelligent, efficient management of the program's complex administrative details. I personally am extremely grateful for her sense of humor, helpful advice, and generosity.

Over the years, my fellow coaches in the elementary science program have provided their expertise and guidance in developing this program. For more than a decade, Kathryn Show, who was my mentor as I began to learn about inquiry-based science, has helped hundreds of teachers learn to provide high-quality science instruction for their students.

As I began developing the science-writing program, I spent many hours in teachers' classrooms. Four of the master teachers who greatly affected the development of the program later became science coaches. I want to acknowledge and thank Ana Crossman, Kirsten Nesholm, Paula Schachtel, and Mindy Woodbury for their countless invaluable contributions to the program, including their pivotal work in this book, the video episodes, and the Stories from Schools section on the website. To be able to feature their work in *Writing in Science in Action* fills me with great joy.

In developing the video episodes for this project, I called on other master teachers to whom I will be forever indebted for putting themselves on the line in front of the cameras in order to show other teachers across the country how to implement this approach. These stellar teachers are Nani Castor-Peck, Dan Jordan, Stephanie McPhail, Christine Patrick, Joni Pecor, and Deb Schochet (who also contributed to the Stories from Schools section on the website).

In the video episodes that feature the science-writing group meetings and the teacher-student conferences, Katie Renschler (who began developing the writing approach with me in 1996) and Mindy Woodbury are fabulous as facilitators and commentators, presenting a picture of the value and the substance of these meetings. They were supported by their knowledgeable and insightful colleagues: Althea Chow, Dan Jordan, Jeannie Revello, Matthew Snyder, Ana Crossman, Shelly Hurley, Joe Kunkel, and Elyse Litvack. Dan and Joe also showed us how we can have meaningful conferences with our students.

I also have been honored to have worked since 2000 with the Lead Science Writing Teachers team, a group of more than fifty teachers who meet almost monthly during the school year. Through the years, they have provided continual feedback that I have used in refining the program in Seattle and beyond. Those who have served on the team for at least three years during the current NSF project include all the teachers I already have mentioned as well as: Kamilah Abdul-Alim, Chantel Anderson, Lynn Barnicle, Lisa Boveng, Jim Buckwalter, Heather Christothoulou, Whitney Denney, Diane Eileen, Paula Eisenrich, Liz Filep, Erika Haberly, Tamra Hauge, Theresa Healey, Ann Kumata, Kathy Langhans, Vernon Larsen, Joan Lassiter, Shawn LeValley, Theresa Lourde, Bernie McDonough, Marilyn Mears, Huong Nguyen, Kit Norman, Doris Toy Patin, Lauren Porter, John Revello, Tim Salcedo, Karma Sawka, Ann-Marie Spata, Jessica Thomashow, Marian Wagner, Katie Weinmann, and Patsy Yamada. The team includes two valuable members from outside Seattle: Laurie Rich, Tukwila School District, and Nina Wolsk, Edmonds School District.

During our NSF-supported project these last five years, we have benefited greatly from a number of talented teachers who generously contributed their time and expertise in order to field-test the materials in this project. I would like to publicly thank the leaders in their districts for supporting this work: Susan Giessaking, Gilbert Public Schools in Arizona; Lynn Farrin, Maine Mathematics and Science Alliance; Dr. Betty Young and Sara Sweetman, Guiding Education in Math and Science Network at the University of Rhode Island; Pat Bobbitt and Stacy Hashe, Anderson School District One in South Carolina; Andrew Schwebke, Puyallup School District in Washington; Jane Goetz, Renton School District in Washington; and Mark Cheney and Julie Vavricka, Yakima Public Schools in Washington.

I also would like to honor and thank Pat Hunter, the phenomenal principal of Maple Elementary, a Blue Ribbon School in Seattle Public Schools. She not only has been an intelligent, ardent, longtime supporter of science education and science writing, but she also generously contributed her time to write a powerful testimonial for the Stories from Schools section on the website.

Seattle's elementary science program has benefited greatly for more than a dozen years from our relationship with Stamatis Vokos, a professor of physics at Seattle Pacific University, and his colleague, Lezlie deWater. They are the experts we go to when we need help with physical science concepts and inquiry instruction. Many of us also have had adult content instruction from them and learned through those experiences how excellent inquiry instruction can enable anyone to learn physics concepts.

From almost the inception of the science-writing program, we have had the privilege of working with the program evaluators, Inverness Research, Inc. Katherine Ramage, Laura Stokes, and Heather Mitchell have been extraordinarily generous, insightful, and supportive through all these years. This program never would have served students and teachers as well as it does without their invaluable contributions.

Susan Mundry of West Ed, as an advisor to our NSF project, also has been generous in sharing her extensive expertise, especially in terms of creating effective professional development resources for teachers.

I want to thank Karen Worth and Jeff Winokur of the Educational Development Center for their support and advice over the years as well as for the opportunities they have given me to share our work at conferences. They are an inspiration to anyone who believes in the paramount importance of high-quality science instruction.

One of the most rewarding professional experiences I have ever had is working with True North Studios to develop the video episodes that accompany this book. Michele Costa, the producer, is extraordinarily gifted, not only in all the mysterious details of production but also in quickly understanding what teachers need to see in order to understand how to implement this approach. Furthermore, she is a gracious and empathetic soul who put all the teachers at ease despite the fact that two large cameras were zooming in on their every move. Bill Purdy, who handled the technical aspects of making the DVD, is also a talented professional to whom I am grateful for helping make the video episodes such a stellar part of this project. I also want to thank Julie McMackin, another member of the team, for taking the wonderful photographs for this book.

I am deeply indebted to Katherine Bryant, the lead editor of Math and Science at Heinemann, for her brilliant help and kind support in the shaping of this book. I also want to thank Victoria Merecki, the production editor, not only for so carefully managing all the production details but also for her thoughtful comments. Kate Montgomery, the publisher, and the rest of the Heinemann staff I have worked with have been extremely generous and knowledgeable as well.

As I said in *Writing in Science*, I was an editor before becoming a teacher, and like most editors, I go to battle with every sentence I have to write. I want to thank the friends and family members who so patiently have supported me during this long project. I particularly want to thank Ana Crossman, who has been so gracious about listening to my concerns and questions and then providing thoughtful and wise counsel. My niece Kimberly, an aspiring conservation zoologist, is an unusually insightful eleven-year-old who has offered, from a student's perspective, much humorous and useful advice about teaching. Deb Easter has kindly acted as editor-at-large through countless phone calls that always result in humorous, intelligent, and pragmatic advice that I greatly value.

To my children—Derek, Jonathan, and Kate—I am deeply grateful for their ongoing patience, support, intelligent advice, and humor during the last few years as I have been immersed in this project. I am more proud of being their mother than of anything else in my life.

Finally, I want to pay tribute to Lynn Barnicle, to whose memory our work has been dedicated since her death from leukemia in 2009. She was a longtime, dedicated member of our science-writing team, a master teacher, an ardent proponent of science education as well as of the arts and social studies, and the kind of human being we value beyond measure when they grace our lives. In spirit, she remains with us as a poignant and urgent reminder that all students need to have a strong science education so they can participate knowledgeably in our increasingly complex world. Some of them will be inspired to study at the highest of levels to become the scientists who develop cures for diseases that take such gracious and radiant human beings from us long before their time.

Introduction

A teacher shared this story with me at a national conference: On the first day of school, a mother was telling the teacher about her son, who receives services in special education. She said, "You'll never be able to get him to write. It's such a struggle for him." At a parent-teacher conference several months later, the teacher shared the boy's science notebook with his mother. When the mother saw the amount and quality of the writing in her son's notebook, she burst into tears and said, "How did you get him to do this?" The teacher replied, "I never expected him not to."

This is not an uncommon story for teachers who have high expectations for each of their students and who teach inquiry-based science and science writing using the methods you will find in *Writing in Science in Action*. Because of the scaffolding and modeling described in this book and its predecessor, *Writing in Science*, students with all levels of academic skills move to higher levels of achievement in both science and expository writing.

When I wrote *Writing in Science* in 2006, I had spent a decade, first in my own classroom and then working with over a hundred teachers in Seattle Public Schools, developing an effective, meaningful approach to teaching scientific thinking and writing. Since then, I have spent five more years developing, field-testing, and refining new materials, including video episodes that show teachers as they implement the approach. The result of these efforts, *Writing in Science in Action*, provides strategies, tools, and resources to help you begin to implement the approach with your students or continue what you began as you read *Writing in Science*.

These books and materials have been developed and produced as part of a National Science Foundation (NSF) Teacher Professional Continuum (TPC) grant. Feedback from over 1,200 teachers and reports from the external evaluators of the grant, Inverness Research, Inc. (who interviewed teachers, observed classrooms, and analyzed student work), helped inform the development of the science-writing program and resources in Seattle Public Schools. Evaluation studies of this approach indicate that students whose teachers use this approach have higher scores on standardized state assessments (Herman 2005), produce more sophisticated writing about science, and spend more time doing science than students whose teachers do not use this approach (Stokes, Hirabayashi, and Ramage 2003).

During the current NSF grant, from 2006 through 2011, teachers from Washington, Maine, South Carolina, Arizona, and Rhode Island field-tested the new materials produced after *Writing in Science* was published in 2007. This second book thus reflects eleven years of implementation by teachers in Seattle, which is a diverse, urban school district where students speak over a hundred different languages and about 40 percent of the students receive free or reduced-price lunches, as well as the experiences of other teachers in diverse settings in five states.

Why Does This Approach Matter?

This approach to science and science writing helps develop students' understanding of science concepts, scientific thinking, and writing in four key ways:

1. ***The learning begins with concrete materials as students are actively engaged in "doing science."*** This removes the obstacles that many students face in school because of their language skills, special needs, and other issues. All students start at the same place. This increases their interest, motivation, and, ultimately, their self-esteem and skills in science and writing.
2. ***Literacy skills are acquired in a meaningful context.*** Students do not learn different forms of writing in isolation, apart from authentic experiences. For example, they learn how to write a conclusion after they have completed a scientific investigation and need to share their results with other scientists. This makes the writing meaningful, which increases students' motivation.
3. ***Writing about science concepts and scientific thinking provides students with the opportunity to engage in thinking and types of expository writing that they typically do not encounter at other times in the school day.*** For example, talking about and writing scientific conclusions after conducting investigations and analyzing test results involves high-level thinking and writing skills that fall into the categories of writing to persuade and writing to explain, two purposes of writing that the new Common Core State Standards for English Language Arts emphasize as a means of improving students' literacy skills as they prepare for college and careers (Common Core State Standards Initiative 2010).
4. ***Students are able to become scientifically literate at the same time that they are developing valuable thinking and literacy skills.*** The scaffolding and modeling that are central to this approach help students both construct understanding of science concepts and develop their skills in scientific thinking, scientific skills, and scientific writing.

What's in This Book and How Can It Help You?

I developed the additional resources presented in *Writing in Science in Action* based on what teachers have done, what they say has worked well for them, and what obstacles they have encountered. I have found that teachers typically have three major requests: they want to watch teachers implementing this approach with real students, they ask for help with assessment, and they want strategies and tools that they can use easily and effectively with their students. In order to meet these needs, this book is divided into three parts. An accompanying website provides additional resources.

Part 1: *Writing in Science* in the Classroom

- **Chapter 1:** "Overview" presents the basic components of this science-writing approach. If you have read *Writing in Science*, this will be a useful review; if you have not read the book, the overview will provide the basic information you need to implement this approach in your classroom.

- **Chapters 2 through 7:** Each chapter focuses on a video episode that features a science and a writing session in a different grade (from kindergarten through fifth grade). These chapters present important components of this science-writing approach and resources to help you implement those components.
  - **Chapter 2** explains how to use modeling and scaffolding to help students develop their abilities to work, think, talk, and write like scientists.
  - **Chapters 3 through 6** focus on different types of notebook entries, in roughly the order they might be needed in a scientific inquiry: scientific illustrations, data tables, and observations; scientific comparisons; simple claims supported with evidence; and predictions, graphs, and complex conclusions. Chapters 3, 4, and 6 include checklists that identify the characteristics of an exemplary entry of each type. You can use these checklists in planning instruction and assessing your students' entries.
  - **Chapter 7** includes strategies that support English language learners as they learn science content, scientific thinking, and the language they need to use in communicating about science.

Part 2: Assessment

- **Chapter 8:** "Meaningful Assessment and Effective Feedback" explains the characteristics of meaningful assessment (what do you assess in science notebooks and how do you assess them?) and effective feedback (what do you say to students that helps build their confidence as well as their thinking, content understanding, and writing abilities?).
- **Chapter 9:** "Group Critiquing and Teacher-Student Conferences" focuses on three video episodes that show how groups of teachers work together to plan their instruction and assess their students' notebook entries in productive ways.

Part 3: Teachers' Toolkit

This section focuses on specific areas in which teachers want and need support.

- **Chapter 10:** "Planning Instruction: Focus Questions and Meaningful Notebook Entries" guides you in developing questions that focus students' thinking during and after their investigations. The chapter also helps you plan notebook entries that will deepen students' thinking and content understanding as they write each entry.
- **Chapter 11:** "Sample Minilessons" gives you some lessons to use in teaching your students how to make specific types of entries (for example, scientific observations and conclusions).
- **Chapter 12:** "Emergent Writing" presents some tips and strategies for supporting emergent writers in any elementary grade.
- **Chapter 13:** "Frequently Asked Questions and Next Steps" addresses the most crucial of the broad questions that teachers ask about this approach, then offers suggestions for where to go next as you implement the approach.

Additional Resources

DVD

The **video episodes** on the DVD, which are an integral part of *Writing in Science in Action*, show how teachers implement this approach to teaching science and science writing in real classroom situations. As noted earlier, seven chapters feature a video episode so you can learn from both reading and watching.

Website

The website associated with this book, www.heinemann.com/wisia, provides resources related to both this book and *Writing in Science*. The website is divided into sections as follows:

- **Checklists for Exemplary Notebook Entries**, which are shown in Chapters 3, 4, and 6 and included here in a compact, downloadable form for you to use in planning instruction and assessing notebook entries.
- **Reproducibles** of each of the other forms that appear in the book, and some from *Writing in Science*.
- **Student Notebook Entries, Pre-kindergarten Through Fifth Grade**, which are grouped by type of entry (for example, comparisons, conclusions) and include annotations that highlight different aspects of each student's entry.
- **Guidelines for Science-Writing Group Meetings**, which are designed to support you and your colleagues over a series of meetings as you gradually implement different components of this science-writing approach and reflect together on your instruction and your students' learning. Two versions of the guidelines enable you to use either this book alone as a resource, or this book with *Writing in Science*. Teachers who have had the opportunity to work together in this way say that it profoundly and positively affects how they view their students' work and their instructional practice and increases their enthusiasm about their teaching of science and science writing.
- **Stories from Schools**, which include a testimonial from the principal of a Blue Ribbon School explaining the value of inquiry science and science writing, and stories from four teachers who share their experiences, their insights, and the successes of their students, including those with special needs, English language learners, and students with highly developed academic and language skills.
- **Background Information About the Video Episodes**, which includes answers to typical questions teachers ask after watching each episode (for example, demographics of the school, background of the teacher and students, specifics about the classroom setup).

This Book and *Writing in Science*

Writing in Science in Action provides enough basic information that you can implement the approach without having read *Writing in Science*. If you have already read *Writing in Sci-*

ence, you will find this second book useful because it provides new materials to meet the needs that teachers in the field-test sites identified. If you have not read *Writing in Science*, you probably will find, as you and your students gain skill and confidence, that you want more information. *Writing in Science* goes into more depth about certain aspects of this approach, providing detailed information about the stages of teaching and learning, additional ideas about teaching different forms of expository writing, and an in-depth look at the process of developing a science-writing curriculum for a complete science unit. It also includes more details about the development and components of the Expository Writing and Science Notebooks Program in Seattle Public Schools and research about its impressive, positive impact on student learning and teachers' practices. It features a complete notebook from a student in a class that is studying physical science, and includes captions that describe the teacher's instruction and students' work before they wrote each entry.

In a time when teachers lament that they do not have time to teach science because they are working so hard to develop their students' literacy and math skills, the approach that you learn in *Writing in Science in Action* and in *Writing in Science* enables you to meet your students' literacy needs and at the same time provide them with rich science experiences. Ultimately, this combination will help them develop into scientifically literate citizens in a global community and, perhaps, even become scientists who address the challenges of this complex modern world.

Making and Writing Scientific Comparisons

Video Episode: Ecosystems

Before You Watch

The process of making scientific comparisons deepens students' understanding of the organisms, objects, or events that they are observing and studying. For example, when a student observes sand, she will notice certain properties of that soil component. Then when she observes clay, she not only will notice properties of that soil component but also will discover additional properties of the sand because of the differences between sand and clay. Thus, the process of observing two components broadens the student's comprehension of each one.

In the Ecosystems Video Episode, the teacher chooses to have her students compare and contrast a model ecosystem and a real ecosystem. She knows that when students use models to help them construct an understanding of science concepts, they often do not make connections between the model they are observing and what the model represents in the real world. In this video episode, students go outside to observe a real ecosystem after they have spent several weeks observing models they have made of ecosystems. They then compare the model and real ecosystems and write their comparisons.

While You Watch

As you watch the Ecosystems Video Episode, think about the following questions:

1. How does a class chart like the one the teacher creates with the students in this episode help support students' learning of complex concepts?
2. How does using the box and T-chart strategy help students organize their thinking and develop their conceptual understanding of ecosystems and models?

After You Watch

Some science units, particularly life science units, require students to learn a great deal of information, including new science terms. Visual scaffolding is particularly critical in teaching these units, especially for students who are learning English or who have special needs. As they learn new information, the class makes entries in their class chart, which serves as an organized community record of the important things that the students have observed and learned. In addition, the terms students need to remember are displayed in organized ways (for example, the words that relate to the concept of *producers* are grouped together).

The box and T-chart is another critical visual scaffolding method because it helps students think about their observations and the information they have learned and then organize that information into similarities and differences—in this case, between real and model ecosystems. This then leads to greater understanding of the models and ecosystems.

Overuse and Misuse of the Box and T-chart Strategy

The box and T-chart strategy is a simple and effective way to make comparisons. When used with the Compare and Contrast writing frame (see Figure 11–3 in Chapter 11), all students can be successful at making and writing comparisons. As a result, teachers tend to overuse, and sometimes misuse, the strategy.

In a science unit, use the box and T-chart no more than two or three times. After that, have students *discuss* comparisons during the shared reflection discussion at the end of an investigation, but then have them *write* about something else, such as the relationships they have observed, cause and effect, or what variables they had to keep the same or control in order to make a controlled investigation.

The box and T-chart also can be misused. For example, the following question in a unit about electric circuits would not lead to meaningful writing: "How are conductors and nonconductors similar and different?" The important concept here is how conductors and nonconductors are *different,* because it is some of their distinctive properties that define their function. It is not important that conductors and nonconductors are similar because they are both materials. Having students spend time making an organizer and writing a comparison of the two would not result in a meaningful and, therefore, productive notebook entry. The important thing to consider in planning notebook entries is this question: How will writing this entry deepen the students' conceptual understanding and/or scientific thinking? Using the box and T-chart strategy to compare and contrast conductors and nonconductors will not deepen scientific thinking and/or understanding of science concepts of the unit. Elementary students have limited time, energy, and attention spans. You need to maximize their opportunities for meaningful learning when planning the types of notebook entries they will make.

Strategies for Your Classroom

Notebook Organization Strategies

For many students, it is easier to write a comparison when they can see their notes without flipping pages back and forth. The teacher in this video episode knew that students would need to have their observation notes about the outdoor ecosystem on a left-hand page and their box and T-chart on the facing right-hand page so that students could see their observation notes as they wrote similarities and differences in their box and T-chart. When it was time for students to write a comparison, the teacher had them write it on a loose sheet of notebook paper because she wanted students to be able to read the box and T-chart while they were writing their comparison. When they were finished writing, they taped the sheet of paper on which they had written their comparison onto the next left-hand page.

Strategies for Making Comparisons over Time

When students are observing things that change over time, they actually are comparing characteristics or properties at one point in time with characteristics or properties from another point in time. When observing how a plant has grown and developed, for example, students can look at their data table much as they do a T-chart to compare their observations and measured (quantitative) data about the plant's height and growth on one day as compared with another day.

Figures 4–1a and 4–1b give an example of this kind of comparison. When students investigate how different soil components behave in water, they observe (and draw) the soil and water on one day, then make more observations and drawings a day or more later, in order to discover the settling properties of different soil components.

In Figures 4–1a and 4–1b, Romain has recorded his observations in his drawings of three settling tubes. Such drawings are a kind of data table in which students can record their test results and refer to them as needed. (The settling tube drawings for the first day of these settling tests are on a previous page in his notebook.)

To scaffold the students' entries, the teacher gave them this frame: "Last time, __________, but now __________." She also told the students to report their observations of the soil *and* the water in each tube, and to check their drawings as they wrote. This entry is a good example of supporting students in writing more independently (telling them to report about the soil *and* water, and to check their drawings) while also giving them a very simple scaffolding or writing frame to help them organize and provide details in their writing. The scaffolding enables students to focus on contrasting the last observation (recorded in the earlier set of drawings) with the current observation. This is a highly effective strategy to teach students when they are determining what changes, if any, have occurred over time.

Strategies for Planning Instruction and Assessment

To be able to write an effective comparison, the student must develop a box and T-chart with strong content and organization and must be able to use that organizer with the appropriate language. To focus your planning and assessment on the Three Key Elements, consider the following questions. What do the box and T-chart and written comparison reveal about the student's:

1. Ability to use *scientific skills* (for example, uses accurate, detailed, complete, and objective scientific observations in comparing and contrasting objects, organisms, or events)?
2. Ability to *think scientifically* (for example, notices accurate similarities and differences; organizes them appropriately; distinguishes between an observation and an inference; for example, "I notice the cricket is motionless and headless. I infer it is dead.")?

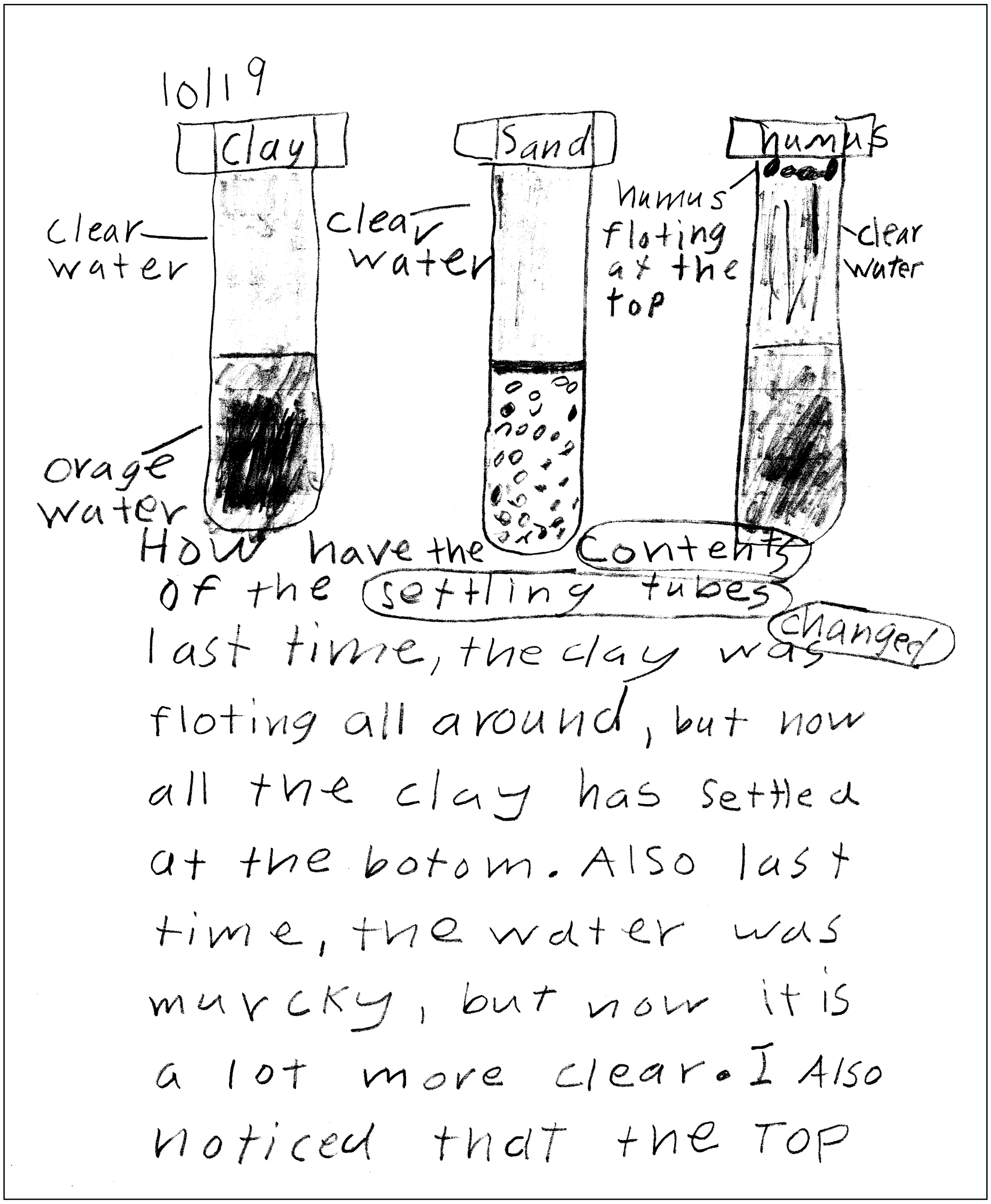


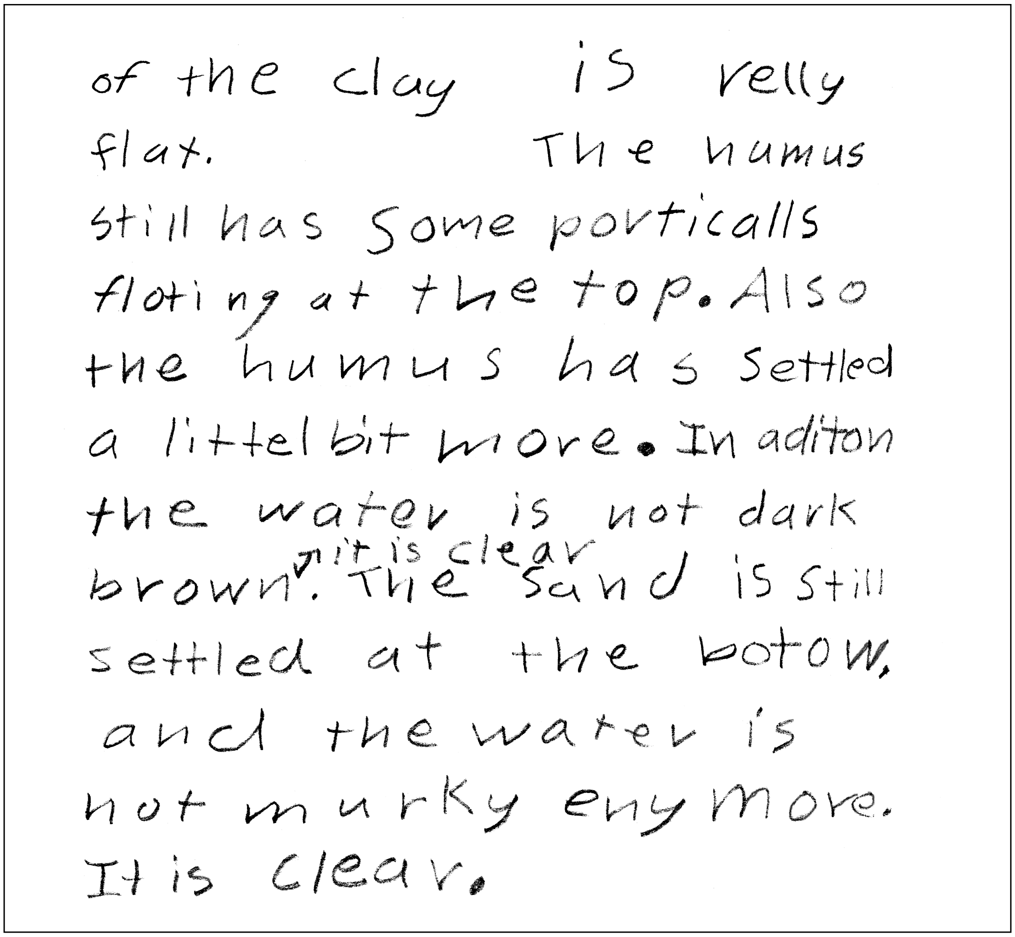
FIGURE 4–1a ***Romain's settling tube drawings and conclusion***

3. Understanding of one or more *science concepts* (for example, includes relevant similarities and differences in the properties or characteristics of an object, organism, or event)?

The checklist shown in Figure 4–2 can be helpful both in planning your instruction and in assessing your students' entries.

Sample Notebook Entries from the Video Episode

Refer to the checklist in Figure 4–2 as you read the sample notebook entries and critiques here.



of the clay is relly
flat. The humus
still has some porticalls
floting at the top. Also
the humus has settled
a littel bit more. In aditon
the water is not dark
brown, it is clear. The sand is still
settled at the botow,
and the water is
not murky eny more.
It is clear.

FIGURE 4–1b ***Romain's conclusion continued***

Notebook Entry: Annie

Annie has a good understanding of the science in the *Ecosystems* unit, but because English is her second language, she does not find it easy to express herself in writing. She apparently has copied the class box and T-chart during the class discussion (Figure 4–3). She also may have copied the first part of the paragraph in Figure 4–4 during the shared writing that the class wrote with the teacher.

When the teacher talks with Annie during the independent writing stage of the writing session, Annie feels stuck. But once the teacher reminds her about the phrase *In addition* and gets her focused on the Compare and Contrast writing frame (Figure 11–3), Annie completes the paragraph and the rest of the entry on her own. The scaffolding helps her express her understanding of the science concepts.

Although it certainly is preferable for students to do their own writing, the fact that Annie completed the rest of the comparison independently indicates that she probably lacks confidence in her writing abilities but is able to write independently once she gets going, with a little support from her teacher. This is a fairly common occurrence with students, including those who are learning English, who are not yet sure of their writing skills. Note also that on her own, Annie uses an effective organizational strategy, putting an X next to each part of the organizer as she includes it in her writing.

Characteristics of an Exemplary Box and T-chart and Written Comparison

Similarities in the box and differences in the T-chart are:

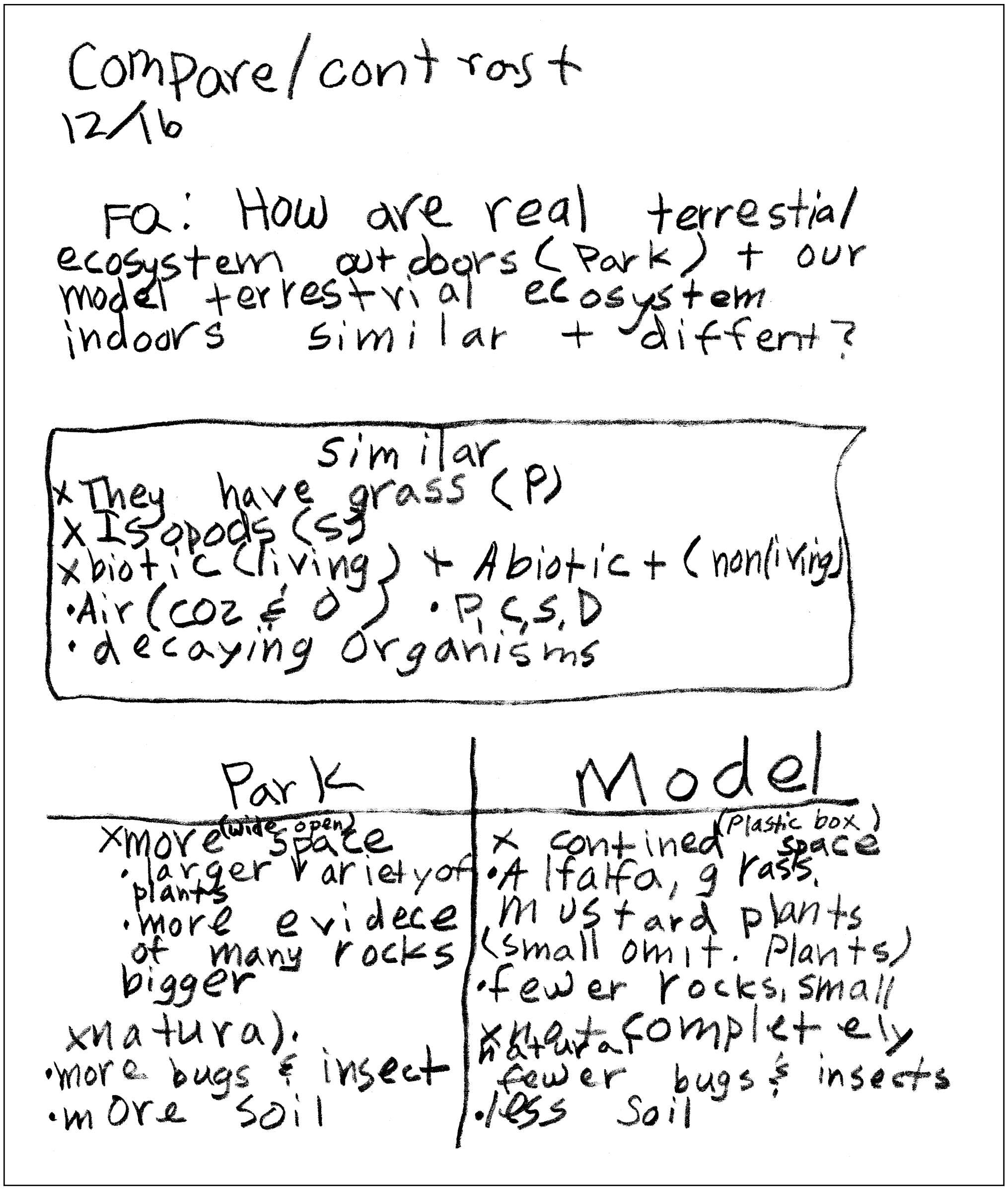
- *accurate*
- *complete*
- *organized, so that each row refers to the same category of information, just as in a data table (e.g., one row includes differences in color; another row includes differences in size)*
- *observable, not inferred*
- *relevant, not extraneous (e.g., the color of a plant's leaves is important because it reflects the health of the plant; the color of a ball is not important because it is not a property that affects the behavior of a ball)*

Note: *Early in a unit, students might not yet have had enough experiences to determine what is relevant.*

Written comparison includes:

- ❑ *descriptions or explanations that are:*
  - *accurate*
  - *complete*
  - *organized*
  - *objective (observable, not inferred)*
- ❑ *relevant similarities and differences*

FIGURE 4–2 ***Checklist for Characteristics of an Exemplary Box and T-chart and Written Comparison***


Compare/contrast
12/16

FQ: How are real terrestial ecosystem outdoors (Park) + our model terrestrial ecosystem indoors similar + diffent?

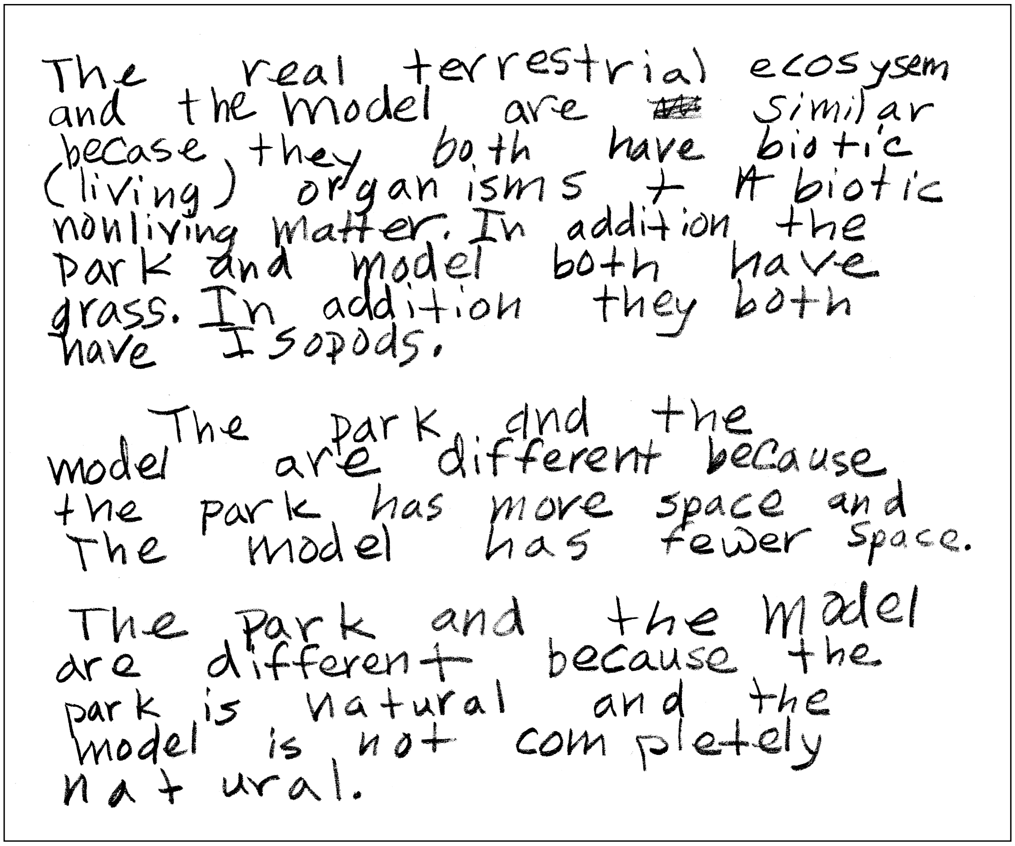
Similar
x They have grass (P)
x Isopods (S)
x biotic (living) + Abiotic + (nonliving)
•Air (CO2 & O) •P, C, S, D
•decaying Organisms

Park	Model
x more (wide open) space	x contined (Plastic box) space
•larger variety of plants	•Alfalfa, grass, mustard plants (small amt. plants)
•more evidece of many rocks bigger	•fewer rocks, small
x natural.	x Natural completely
•more bugs & insect	fewer bugs & insects
•more soil	•less soil

FIGURE 4–3 ***Annie's box and T-chart***

In her box and T-chart, Annie has included similarities and differences that are accurate and complete. The similarities are listed in the box. The differences are included in the T-chart and organized horizontally by category as they would be in a data table. All the characteristics are observable except for the presence of air. But this characteristic is appropriate to include because the class has learned about oxygen and carbon dioxide as they have been observing their model ecosystems over time. The class data table had "P, C, S, D" listed (for "producers, consumers, scavengers, and decomposers"). Scientists reading this entry would wonder what the initials mean, so Annie and other students would need to make the meaning clear either in the box or in the written comparison.

In her written comparison, Annie apparently copied the first sentence from the shared writing the class did with the teacher. But from "In addition" on, she does her own writing. The similarities are accurate, organized, and objective. The information could be


The real terrestrial ecosysem and the model are similar becase they both have biotic (living) organisms + Abiotic nonliving matter. In addition the park and model both have grass. In addition they both have Isopods.

The park and the model are different because the park has more space and The model has fewer space.

The park and the model are different because the park is natural and the model is not completely natural.

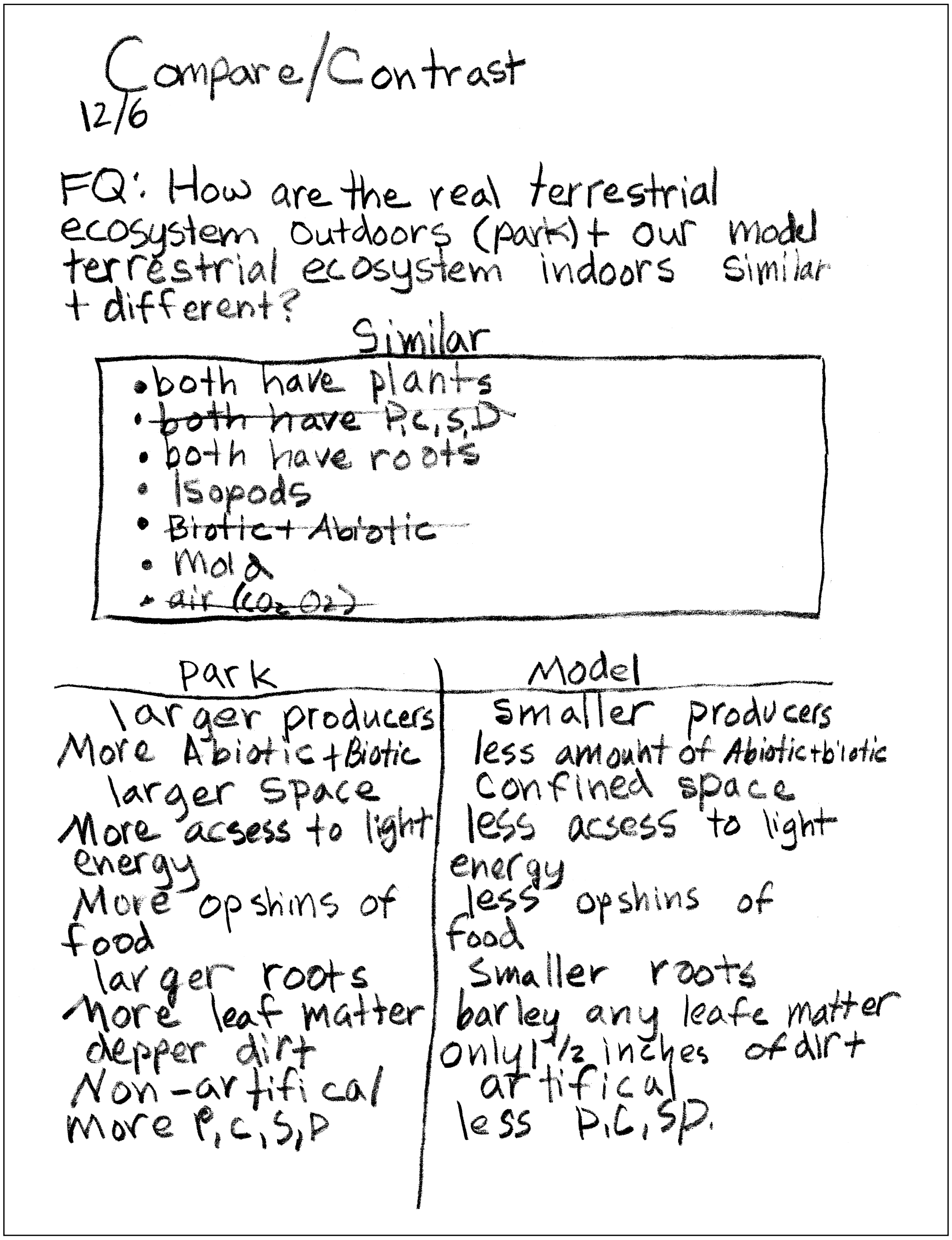
FIGURE 4–4 ***Annie's comparison***

more complete if she had written *producers* instead of just *grass*, which is only one type of producer, and *scavengers* instead of just *isopods*, which are one example of scavengers. A more complex sentence would be, "In addition, the park and model both have producers (for example, grass), consumers (for example, crickets), and scavengers (for example, isopods)."

In the second paragraph, Annie chooses to write about two important differences, both of which are accurate, complete (she would not be expected to include every difference), organized by category, objective, and relevant. "Fewer space" is not grammatically correct, but the teacher (and another scientist) would know what she means. Clarity is more important in this rough draft stage than grammar. And since she is learning English and needs to build her confidence as a writer, the teacher would point out the many strengths in the entry and overlook the grammatical weaknesses, which are a natural part of her language acquisition.

Notebook Entry: Kyra

Kyra, another student in the videotaped classroom, has strong conceptual understanding and strong writing skills. She includes her own ideas in her box and T-chart (Figure 4–5), which she creates during her team's discussion of their model and the park. During the writing session, she chooses to use some of the scaffolding as she writes independently (Figure 4–6).



Compare/Contrast
12/6

FQ: How are the real terrestrial ecosystem outdoors (park) + our model terrestrial ecosystem indoors similar + different?

Similar

- both have plants
- ~~both have P,C,S,D~~
- both have roots
- Isopods
- ~~Biotic + Abiotic~~
- Mold
- ~~air (CO_2 O_2)~~

Park	Model
larger producers	smaller producers
More Abiotic + Biotic	less amount of Abiotic + biotic
larger space	Confined space
More acsess to light energy	less acsess to light energy
More opshins of food	less opshins of food
larger roots	Smaller roots
More leaf matter	barley any leafe matter
depper dirt	only 1 1/2 inches of dirt
Non-artifical	artifical
more P,C,S,D	less P,C,S,D.

FIGURE 4–5 ***Kyra's box and T-chart***

Her entries in her box and T-chart are accurate and she includes most of the important characteristics. (Students are not expected to include every characteristic because there are so many.) The characteristics are organized, in that the similarities are in the box and the differences are organized by category in the T-chart. Except for "air (CO_2, O_2)," she can observe everything, but her inference about air is appropriate, as explained earlier.

The characteristics are mixed in terms of their importance, but that is because the students create the organizer as they are making their observations of their model ecosystems, so they would not be placing each characteristic in order of its importance in the ecosystem. They use that level of thinking when they are writing the comparison.

The real terretrial ecosystem and the Model are similar because they both have Producers, Consumers, Scavengers, and decomposers. Also, they both have Biotic (living) and Abiotic (non-living) matter. In Addition, they have Air both Co_2 and O_2, the O_2 from producers and the Co_2 from the consumers. Those are the similaritys of the ecosystems.

The park and the model are different because there are more biotic and Abiotic matter in the park whereas the model has a Smaller amount. furthermore, the park is a natural ecosystem, but we made the model and it is unatural. Also, the park is a larger Space, whereas the model is a confined space. Those are the diffrentcese of the ecosystems.

FIGURE 4–6 ***Kyra's comparison***

In writing her comparison, Kyra includes similarities that are accurate and complete in terms of the most important characteristics of the ecosystem. In the box, she writes other similarities (for example, *plants*, *roots*, *mold*). But those specific characteristics are in the more general categories she writes about in her paragraph instead: *producers* include plants that have roots, and mold is a *decomposer*.

She writes the second paragraph from a similar perspective, focusing on the relevant but more general differences. For example, she writes about the park's having more biotic and abiotic matter than the model rather than writing that there is more leaf matter and deeper dirt in the park or real ecosystem.

Note that she crosses out the three similarities that she chooses to include in her written comparison. She does not cross out or put an X next to what she includes for differences. She has written a strong comparison nonetheless. Learning to use the checking-off strategy more consistently, however, would help her better organize and keep track of details she wants to include in her writing—often a challenge for students who have strong language and thinking skills.

Other Highlights of the Video Episode

- In this science-writing approach, visual scaffolding is essential to helping students develop their understanding of science, their scientific thinking, their scientific skills (such as making scientific observations), and their abilities to write scientifically. At the same time, however, it is important not to have too much visual scaffolding in the classroom because many students either will overlook what is there or become distracted by it.
- In watching this video episode, some teachers comment about the amount of time and space it takes to create and display all this visual scaffolding. Making word cards and other visual supports is time-consuming the first time teachers teach a unit. But once the scaffolding is in place, teachers need not spend the time again. Many teachers laminate the master chart or table so they can reuse it each time they teach the unit.
- Teachers who do not have a lot of wall space can use flip charts and/or a rolling chart holder. Teachers also put other charts and tables on the white board only during the science and science-writing sessions. Some who teach in open-concept classrooms with no walls put up clotheslines and hang charts and writing frames from them.

Related Material

Chapters

- Chapter 3: "Scientific Illustrations, Data Tables, and Observations" (Plants Video Episode)
  - A prerequisite to being able to make an effective box and T-chart and write a strong comparison is to develop the *scientific skill* of making accurate, detailed, and organized scientific observations.
- Chapter 11: "Sample Minilessons"
  - This chapter includes a sample minilesson on making a box and T-chart and writing a comparison.

Website

- Student Notebook Entries, Pre-kindergarten Through Fifth Grade: Box and T-charts and Scientific Comparisons
  - Read examples of comparisons from your own grade level as well as samples from a grade above and below your level.
- Checklists for Exemplary Notebook Entries
  - Includes checklists for different types of notebook entries (for example, observations, scientific illustrations, and conclusions)
- Background Information About the Video Episodes: Ecosystems