The Role of Children’s Journals in Elementary School Science Activities

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Abstract: This article reports on a study that investigated the ways that children’s use of science journals aided their acquisition of science understandings in one kindergarten and one fourth-grade classroom. The questions for investigation were: how does the child contextualize the science experience on the journal page? How do child-produced graphics on the journal page reflect the children’s experiences with other school texts? The study found that children recontextualized their understandings of the science investigation and phenomena by using three types of mental contexts that were reflected in their science journals: these contexts were imaginary, experienced, and investigative worlds. By drawing on these three worlds or internal contexts, the children were able to pull the external phenomenon into an internal context that was familiar to them. The child’s construction of ideas about a current science experience as expressed on the journal page may reflect experiences with other conventional texts. In this study the children’s representations of their imaginary, experienced and/or investigative worlds were shaped by other texts and structures such as school science texts. © 2000 John Wiley & Sons, Inc. J Res Sci Teach 38: 43–69, 2001

The learning of science is an active, continuous process whereby the learner takes information from the environment and constructs personal interpretations and meanings based on prior knowledge and experience (Driver & Bell, 1986). Children construct models of the workings of written language by interacting with people and objects in their environment (Genishi & Dyson, 1984). They simultaneously construct understandings of science phenomena that may be reflected in both their writing and drawing (White & Gunstone, 1992). This view undergrids an approach to teaching wherein children learn science by “doing science” and use writing as part of their science experiences (Edelsky, Altwerger, & Flores, 1991). This suggests that in the context of science activities child-produced journals would promote the use of literacy while clarifying and verifying children’s emerging theories about science phenomena (Neuman & Roskos, 1993).

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The use of language arts journals has been well explored in terms of literacy teaching and learning (e.g., Lindfors, 1987; Morrow, 1997; Routman, 1991; Salinger, 1996; Tompkins & Hoskisson, 1991), but studies of the use of journals in science teaching once were rare (Elstgeest, Harlen, & Symington, 1985). In elementary classrooms, language arts journals are frequently used to provide children with opportunities to differentiate their graphic and/or written representations from oral representations of their knowledge (Britsch, 1994). To expand our understanding of children’s science learning, then, we need to examine children’s activity across a variety of dimensions, including observing the ways children approach science experiences, how children interact with peers, and the products they create—the drawings, writings, and constructions children make to represent their understandings (Doris, 1991).

Theoretical Framework

Learning involves both a personally and a socially negotiated construction of meaning (Cobb, 1990). In the classroom context this means that children develop cognitively “by being agents in their own learning” (Wells & Chang-Wells, 1992, p. 49). The view of agency to be advanced here is based upon three central premises: (a) that children construct scientific concepts by drawing on their existing ideas and experience (Rieber & Carton, 1987), (b) that social interactions both direct and indirect mediate knowledge construction (Vygotsky, 1986), and (c) that knowledge is personally constructed by the learner based upon both prior ideas and social interactions (Tobin & Tippins, 1993).

Elementary school children develop their own models of both the forms and functions of oral language by interacting with people and objects in their environment (Halliday, 1980). Similarly, the acquisition of written language can be included as part of this socially constructed process (Genishi & Dyson, 1984). Children’s drawings can represent their recollections of events, providing a record of an experience and their understandings of that experience (Dyson, 1985). Thus, while children’s graphics may realistically document events, children may also use these to contextualize experiences in different ways. According to Piaget young children’s drawings are realistic in intent; that is, children draw what they think rather than what is visually accurate. Similarly, Vygotsky (1978) referred to drawing as graphic speech and noted that young children’s representations often reflect what they know about the object more than what is actually perceived. Young children name and designate more than represent.

A neglected aspect of children’s representations is that they can act as a guide to children’s understandings (Elstgeest et al., 1985). Children may convey their understanding through drawings that represent phenomena and events. Children incorporate different selections of such details in order to draw the experience into a context that makes sense to them, whether a past experience, a similar text, or an on-going social interaction. As a result of this contextualization process (Donaldson, 1978; Ochs, Taylor, Rudolph, & Smith, 1992), children’s drawings may tend to emphasize some features of a phenomenon more than others. It follows that by creating their own science journal pages children are able to impose their ways of seeing and thinking about the science phenomena, constructing or reconstructing the phenomena through their own lens of experience (Shepardson, 1997). Children’s self-produced journal pages may be viewed as a story that unfolds as the observed phenomena change over time, a story molded to fit the children’s way of seeing; therefore, the story may be distorted from that of the scientist or teacher (Shepardson, 1997).

Young children also use their dramatic and narrative language, for example, to create “imaginary worlds” (Dyson, 1989). As child authors mesh their “experienced worlds” with their imaginary ones created through narrative, both authors and readers are enabled “... to
connect within the ongoing social one” (Dyson, 1989, p. 11). This suggests that children’s understandings of science concepts might also be embedded in a network of social and symbolic relationships. Graphic activity (i.e., writing and/or drawing) in science journals could then provide a window for looking at how children connect their experienced and imaginary worlds with the investigative world of the science experience. Drawing and writing produced in a science investigation are valuable because they allow children to express their ideas and findings; they take on the role of talk with regard to assisting children in making meaning of their ideas (Harlen, 1988).

Recent Research on Children’s Use of Journals in Science

In the elementary science curriculum journals have served primarily as logs in which children simply maintain records of experiments and lists of results (Watson, 1987). This process of logging experiments and results limits children to a mastery of the traditional discourse and rules of school science: using vocabulary, memorizing facts, following procedures. Science learning is constrained, however, if it is viewed simply as the memorization or logging of rule statements. Learning is more than simply knowing a rule: it is knowing “how to go on” (Giddens, 1982, p. 31), but Saul (1996, p. 9) points out that many textbook and science kit programs reinforce this sort of misguided “hypothesis syndrome.”

Students have somehow come to believe that the job of a scientist is to ask a question, correctly guess the answer, and then “do something” to convince others that their guess was correct. Although this scenario may mimic the reporting structure adopted in scientific journals, it does not, in fact, mimic scientific research. (Saul, 1996, pp. 9–10)

Thus, the child’s entry on the journal page must function as more than a means of reporting teacher-expected results. In fact, scientific literacy should be differentiated from science literacy. Although science literacy focuses on accumulating scientific facts, scientific literacy “…emphasizes scientific ways of knowing and the process of thinking critically and creatively about the natural world” (Maienschein, 1998, p. 917). For example, one fourth-grade investigation of adaptation and evolution of cockroaches combined scientific inquiry with the use of the children’s own research journals (Caswell & Lamon, 1998). Caswell and Lamon found that when children created self-produced journals instead of completing teacher-created products the amount of writing the children did increased; the children did more than simply observe and were more involved in the investigation. Caswell and Lamon’s data also suggest that the children’s journal writing enabled them to organize collected information in novel ways, to develop hypotheses and investigations, and to interpret and explain on the basis of collected information.

Hanrahan (1999) investigated secondary students’ affirmative dialogue journals in learning science. Although Hanrahan could not verify the impact of journal writing on students’ learning, the journal writing did encourage students to participate in their own learning, providing students with a sense of self-worth. In fact, Geddes found that no single reason or goal is “more successful or important than any other when using journals to enhance the learning process” (1992, p. 4). She identified three criteria that characterized the successful use of journals in education:

(1) A definition of what is meant by the term journal in the particular discipline or class;
(2) A decision must be made regarding how the use of the journal will be integrated into your instructional practices—e.g., what goal(s) is journal writing going to help
achieve; . . . will the writing be free form or will there be a specific focus to pursue in developing entries; and (3) A determination of the method, if any, of formally evaluating journal entries/activities. (Geddes, 1992, p. 4)

While children’s science journals may be defined as a purposefully focused genre, the technical tools of science provide children with different perspectives of science phenomena, enabling children to learn science by changing, extending, or enhancing their observations (Shepardson, 1999). The manner in which children engage in science activities, the equipment they use, the procedures they follow, and their conversations influence the meanings children construct, and the journal entries they produce. Thus, psychological tools provide children “with a lens, a way of seeing phenomena, as well as a way of talking, acting, and thinking about phenomena” (Shepardson, 1999, p. 629).

Young children’s journal entries tend to emphasize everyday language versus the use of scientific words, with many of the words used as tools for labeling versus tools for explaining (Shepardson, 1997). Children’s journal entries are often contextualized with reference to either the classroom science activity or the children’s informal experiences (Shepardson, 1997). The nature of children’s contextualization of the science phenomena and activity on the journal page are dependent on the children’s familiarity with the phenomena and materials and equipment. In unfamiliar situations the children’s entries reflected the immediately observed science investigation, whereas in familiar situations the children’s entries are based on their experiences with the phenomena, “placing the science investigation into a real-world context” (Shepardson, 1997, p. 883).

For example, in a study investigating second graders’ use of dialogue journals in science activities, the children’s first writing tended to take the form of a narrative or “procedural recount” (Reddy, Jacobs, McCrohon, & Herrenkohl, 1998, p. 95) about the process of doing the science activity. Children often attempted to outline the procedure they followed in carrying out the activity, resulting in a recipe-like genre that could function as a set of instructions for others to follow. Beyond this, children were sometimes able to offer written outcomes of, but not explanations for, the science phenomena they investigated. The children’s written responses to the teacher’s requests also often drew on their own real-world, experiential knowledge instead of the premises established in the science investigation itself. This experiential context was also incorporated into the children’s journal entries through the inclusion of information about the social interactions they had with others in the course of the activity, reflecting such concerns as social status, group dynamics, and cooperation issues. In groups that were successful, this socially oriented writing also tended to embed recounts of the children’s strengths in carrying out the activity in their recount of the science procedures themselves. Children’s recounts might mention how well one child worked with another on a particular task, for example.

One caveat about the use of dialogue journals for science, however, is that while they may engage children in solving problems, they less frequently engage children in finding problems (Reddy et al., 1998, p. 104). While children may be quite interested in and excited about carrying out science activities, they may not be as willing to spend time interpreting their results. Dialogue journals have the potential to move children beyond simply completing the task to making sense of the task. In this way these journals can support the development of children’s scientific thinking.

This article will present the findings of a project that observed kindergarten and fourth grade children’s uses of written language in individual science journals. Specifically, this report examines children’s use of self-produced journals in two classroom science activities, focusing on the following questions:
How does the child contextualize the science experience on the journal page?
How do child-produced graphics on the journal page reflect the children’s experiences with other school texts?

Method

In line with our theoretical framework, we used qualitative methods of data collection and analysis to document classroom activity and to derive a comprehensive interpretation of that activity (Genishi, 1982). We used a case study method to develop records of children’s approaches to journal use in small-group science activities throughout the academic year in which the study was conducted. This method allowed for detailed study of children’s approaches to journal use, the development of their science understandings, and the evolution of children’s literacy skills in the context of science investigations.

Design of Study

This study was carried out in one kindergarten and one fourth-grade classroom. These grade levels were identified for the study because relatively little classroom-based research has been conducted on the integration of children’s science learning and literacy capabilities in elementary schools. The kindergarten level was selected because it provided an opportunity to investigate: (a) children’s initial science understandings prior to extensive formal schooling, (b) the emerging literacy abilities of very young children in the context of their developing science understanding, and (c) social interactions between peers in the specific context of science experiences, not yet widely investigated for 5-to-6-year-old children. The fourth-grade level was selected because it provided opportunities to investigate: (a) children’s science understandings following more extensive formal science learning, (b) elementary school children’s abilities to use science writing (as opposed to writing in the language arts curriculum alone), and (c) older children’s participation in a variety of more complex science experiences than those used with very young children.

The children in both classrooms were observed throughout the course of one academic year in a number of different science activities. This provided multiple contexts (i.e., different small-group peer arrangements, science content and phenomena, and science investigations) for looking at social interactions, journal use, and evidence of conceptual understandings. The duration of each instructional period and data collection varied depending on the science content and the grade level: each kindergarten science activity lasted for 2–3 days, while fourth-graders’ explorations of a single science phenomenon sometimes lasted for more than 2 weeks.

Participants

The elementary school is located in a middle-class area in a Midwestern community near a major university. The total enrollment of the kindergarten class was 18; 20 children were enrolled in the fourth-grade class. The ethnic composition of the kindergarten classroom was five children of Asian or South East Asian descent; one child was of African American descent; the remaining 12 children were Anglo-European. All 20 children in the fourth-grade were Anglo-European. The socioeconomic background of all children was middle to upper-middle class. After an initial 4-week period of observation and evaluation, six focal children were selected in each classroom for more specific case study. The sample of focal children consisted of three boys and three girls from the kindergarten and two boys and four girls from the fourth grade. The focal
children were judged by the teachers and researchers to be developmentally on course (i.e., not exhibiting any linguistic, cognitive, or social delay) and English-speaking (i.e., not enrolled in English language instruction). The focal children were also judged by the researchers to utilize a variety of approaches to graphic representation (i.e., drawing or writing or both) and to social engagement with teacher and peers.

The two teachers who participated in this study had previously incorporated journals into curricular areas other than science. Because these teachers were experts in integrating children’s self-produced journals into content area instruction, they were invited to participate in this study integrating children’s self-produced journals with science teaching. Both teachers had over 10 years of classroom experience at their respective grade levels, and were enthusiastic about teaching science. These teachers consistently used inquiry methods incorporating manipulative materials in their science programs. Both were interested in learning about children’s writing as a part of science learning. The researchers met with the teachers in order to clarify both the forms and the meanings conveyed in the children’s journals and to plan instructional methods based on the children’s understanding of science phenomena. This format allowed the children’s journals to serve as tools for both research and instruction.

Data Collection

Primary data sources for this study included audio and videotaped recordings of both whole-class and small-group classroom practice in order to document the social interactions and the use of journals in science activities. All children’s journals from each classroom and for each science activity were photocopied as artifacts of children’s understandings and actions. Informal conversational interviews (Patton, 1990) were conducted with both teachers and children in order to obtain their interpretations and explanations of spontaneous events that occurred during the science activities. These informal interviews allowed us to probe teachers’ and children’s understandings of the science phenomena, journal entry content, and social interactions that occurred within the context of instruction. For this reason a single interview protocol of invariant questions was not used. The researchers also compiled field notes documenting the various levels at which the children’s activity was observed (Corsaro, 1985). These included: (a) theoretical notes (Corsaro, 1985), (b) methodological notes (Corsaro, 1985), (c) contextual notes and (d) developmental notes pertaining to each case study. For definitions and examples of the various types of field notes, see Table 1.

Data Analysis

Methods of single- and cross-case analytic induction (Patton, 1990) were combined to analyze the data. Each researcher read the verbatim transcripts of both the audiotaped interviews and the videotaped instruction. We individually analyzed each child’s journal entries in light of the field notes and the transcripts of instruction. We then constructed a set of categories that allowed us to describe individual patterns as well as patterns across cases. The construction of case records also allowed individual patterns within and across the 12 cases to be identified. This analysis included the identification of the children’s uses of journals to construct and reflect upon their understandings of science phenomena. Triangulation was insured through the use of multiple data sources and methods of data collection, and through the analyses developed by both researchers (Denzin, 1978; Patton, 1990; Strauss, 1987).

Investigations, phenomena, and materials acquired meaning as children reframed them in the light of other contexts, or other “worlds,” so to speak. We constructed coding categories that
Table 1
Types of field notes

<table>
<thead>
<tr>
<th>Type of field note and definition</th>
<th>Kindergarten examples from field notes and explanations</th>
<th>Fourth grade examples from field notes and explanations</th>
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</thead>
<tbody>
<tr>
<td>Contextual notes</td>
<td>“N. talks to D., when he shows her the journal, about the letter being backwards. He goes back to the table and looks behind him, says, ‘I was working this way and it goes this way.’ He looks at alphabet posted on wall.”</td>
<td>“B &amp; K control materials. Sts start playing (testing) materials without a plan—trial and error problem solving.”</td>
</tr>
<tr>
<td>Notes that detail the physical and interactional context, clarifying children’s activity or highlighting outstanding occurrences.</td>
<td>This explains the appearance of lower case “b” instead of a lower case “d” for the word “dissolve” on N’s journal page. This links the child’s physical activity with his literacy product in the context of this situation.</td>
<td>The note describes the children’s approach or activity toward the rubber band task: materials controlled by “B” and “K” and trial and error problem solving. The note contextualizes the children’s activity and their writing/drawing on the journal page as being reflective of trial and error problem solving.</td>
</tr>
<tr>
<td>Theoretical notes</td>
<td>“They draw and accompany with writing what the experience is for them.”</td>
<td>“‘Being’ there is not just an event, but an event that is shared—children’s science journals are the same, by being the same students become into ‘being’, they share the event.”</td>
</tr>
<tr>
<td>Notes that explain observations or events based on existing theory or the observer’s understanding of the event; may lead to syntheses of past observations or questions for further investigation: “Play around the outside sandbox is similar to play in the playhouse in that the children go through or produce household routines” (Corsaro, 1985, p. 26).</td>
<td>The field note reflects Piaget’s theoretical point that children draw their perceptions of an experience, not objective reality. The note is based on theory that explains immediately observed child activity.</td>
<td>The field note reflects Bakhtin’s view about shared events, explaining why children’s journal entries are the same, leading to the view of children’s group work in terms of establishing a shared event.</td>
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</table>
reflected the set of “worlds” in our collected data. Dyson (1989) pointed out that children’s evolving ways of composing text often combine elements from an imaginary, distanced world with the child’s current experienced world. Children’s talk while composing can also involve and intersect with the ongoing social world of classroom relationships. This juxtaposition of worlds is evidenced in the content of the children’s texts. Similarly, as we examined the children’s creation of science journal texts, a set of “worlds” emerged: investigative, imaginary, and experienced. These were not a priori coding categories but distinctions we drew in order to characterize differences we saw in the ways that children interpreted their science experiences and expressed their understandings (see Table 2 for operational definitions of coding categories).

<table>
<thead>
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<th>Type of field note and definition</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Methodological notes</td>
<td>“Did 2 substances and we’ll finish after library. Teacher would rather finish it all today.”</td>
<td>“C &amp; B continue working together testing their ideas, while M &amp; K work independently. See what they share about findings.”</td>
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<tr>
<td>Notes that suggest methods or approaches for collecting future data about individuals, situations or events, based on current observations: “I will want to observe interactions around the outside sandbox when I begin participant observation” (Corsaro, 1985, p. 26).</td>
<td>The library visit perhaps also interrupted the children’s process of linking each substances with the science concept. The implication for the design of future science experiences was the need to limit the time and complexity of each activity. This relates to the design of the study in the ways children use their journals.</td>
<td>This note indicates to the researcher to attend to what ideas and findings these students share at a later date. It directs future observations toward the ideas and findings these children share.</td>
</tr>
<tr>
<td>Developmental notes</td>
<td>“Teacher commented that D. couldn’t identify rectangle or colors. She’s not sure if he’s visual or auditory learner. My idea: He focuses on what he wants to focus on ‘…or if he can make a story out of it’ (Teacher’s comment).”</td>
<td>“K draws bottles &amp; spoon. No prediction for sound, but provides explanation based on ‘color’. ”</td>
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<tr>
<td>Notes that describe individual developmental factors that affect the way in which the child carries out the activity.</td>
<td>This is a developmental concern because it refers to the child’s ability to identify shapes and colors in the context of the manipulative activity.</td>
<td>This note is developmental in that K is focusing her explanation on the ‘color’ of liquid versus volume of liquid; some children at this developmental stage are not able to differentiate erroneous variables from pertinent variables or control variables in the demonstration. On the surface, this mimics centration, but this may not be the mental process that is occurring.</td>
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Table 1 (Continued)
They did this by relating the science experience to other real and imagery elements of their lives through the intersection of these worlds. These “multiple worlds” (Dyson, 1989) provided the lenses through which we viewed the children’s constructed understandings of classroom science experiences.

Results and Discussion

We present two assertions that detail the moment-to-moment workings of the science investigations that took place in these two elementary classrooms. For each assertion we first present the kindergarten data and discussion, followed by the fourth-grade data and discussion. This organization, however, does not reflect an implicit developmental comparison; that is, we do not suggest that there is a normative progression to children’s use of realistic versus imaginative ways of representing what they understand. We conclude the article with a discussion of the overall results. The first assertion details the different ways children in these classrooms contextualized the science experiences on the journal page. The second assertion describes how other texts and structures such as school science texts shaped the children’s representations on the journal page.

Assertion 1. The children in these classrooms contextualized science experiences in different ways. They did this by graphically reflecting different “worlds” (Dyson, 1989) or mental contexts in their journal entries: (a) the world of the imagination, (b) the world of previous experience, and (c) the world of the science investigation itself.

For some children it was necessary to pull the visible, external source of the science experience (i.e., the raw materials and/or phenomena of the investigative world) into their own more familiar, internal imaginary and/or experienced worlds in order to interpret and understand the immediate science experience or phenomenon. Other children confined their interpretation of the science experience to the investigative world; the manipulative materials necessary for carrying out the activity inserted another level—or “world”—for children to focus on. Still other children integrated the use of more than one of these worlds to construct understandings of the science phenomena, externalized on the journal page.

<table>
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<th>Table 2</th>
<th>Conceptual Description of Imaginary, Experienced, and Investigative Worlds</th>
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<tbody>
<tr>
<td>Imaginary world</td>
<td>A mental context reflected graphically on the journal page and drawing upon the child’s creation or recollection of make-believe characters, settings, and events. Integrated with the child’s experience of the science activity, this imaginary context provides a framework into which the child can integrate the science content, thus constructing a personal understanding of the relevant science phenomenon.</td>
</tr>
<tr>
<td>Experienced world</td>
<td>A mental context reflected graphically on the journal page and drawing upon the child’s prior real-world experience that is integrated with the science experience at hand. This combination provides a framework into which the child can construct a personal understanding of the relevant science phenomenon.</td>
</tr>
<tr>
<td>Investigative world</td>
<td>A mental context reflected graphically on the journal page and drawing primarily on the child’s immediate experience of an ongoing science activity. The science experience itself provides the framework for the child’s construction of a personal understanding of the relevant science phenomenon.</td>
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Kindergarten. In the kindergarten, the children participated in an investigation of dissolving that took place over the course of 3 days. Each day the children engaged in science activity for 30–45 minutes. The kindergartners’ investigation began with a child-dictated list of definitions of the word “dissolve.” For several of the children in the whole group, the fact that things “dissolve in water” was most salient; for others, “dissolve” was synonymous with “disappear.” Other interpretations analogized dissolving with children’s previous experiences. Nicholas, for example, did not separate the process of dissolving from a previous activity on diffusion. Similarly, Deana equated “dissolve” with “something white,” recalling the previous week’s science investigation of differences in the properties of salt, sugar, baking soda, and flour. Tina responded with, “Vegetables or fruit” when asked what “dissolve” meant to her. When the teacher asked her where her idea came from, Tina said that the dissolving substances reminded her of the colors in the blender at home when her mother pureed fruit and vegetables for “smoothies.”

At tables in their small groups, the children next tested sugar, salt, soil, and sand using chemplates and eyedroppers of water to discover whether or not these substances dissolved in water. The children summarized the results of this procedure on individual data tables stapled into their science journals. This provided a structured response to the phenomena in the investigation based on the children’s observations (A sample table is shown in Figure 1).

A more open-ended type of response was possible on the next page of the children’s journals. Headed with, “What I learned about _______” this page provided a blank space where the children could draw or write what they had learned about the process of dissolving on the rest of the page. In the teacher’s view, the focus of the children’s science journal use was the children’s uses of language and literacy to record and convey science understandings. She began Day 2 with a whole group discussion in which she tried to elicit the children’s explanations for contradictory findings recorded on the data tables. She asked two children whose charts indicated that salt did not dissolve to explain how they had decided that. Neither child responded so the teacher gave instructions for completing the blank page of the science journal:

Teacher: Be thinking about some things that you could put down about what you find out about—I investigated and what I discovered about dissolve. What would you do if you were going to draw something to show us, Melissa?
Melissa: The salt in the pan.
Teacher: You’d draw the salt. What else did we have?

The teacher continued to elicit examples, after which the children went to their tables and got their science journals. At this point, the teacher wrote the word “dissolve” on the blackboard and instructed the children to write or copy the word in the blank at the top of the page. Then she said, “Draw a picture of our little pans.” This instruction focused on the investigative world quite specifically. Despite this direct instruction to draw the chemplates, Sam, one of the focal children, asked the researcher, “Whaddya do? Do ya just write ‘dissolve’ or whaddya do?” In an attempt to clarify, the researcher replied, “What you do is—can you draw what the stuff that you put the water on—what did it look like after we put the water on?”

Sam: (no reply)
Researcher: What did we have?
Sam: Salt.
Researcher: What else?
Sam: Soil.
Researcher: So what happened when we put the water on that stuff?
This interchange, heard by all of the focal children, was more open-ended than the teacher’s instructions but both suggested the investigative world. It was the children who distanced this to link the dissolving activity with their imaginary and experienced worlds. In the dissolving investigation, the focal children most frequently relied on imaginary worlds to contextualize their ideas about the science experience. For example, Deana’s journal drawing (shown in Figure 2) depicted an imaginary world where a duck walked across a beach. As Deana explained, “She [the duck] doesn’t like that dirt mixing up with the sand between her toes because it’s [dirt] too messy and it’s dissolving.” Although Deana had linked her whole-group brainstorming about dissolving to the previous week’s activity, the introduction of new substances (i.e., soil and sand) provided a set of new variables (i.e., color and texture) for testing a substance’s ability to dissolve. These variables became more salient during the small-group investigation and resulted in the creation of a make-believe duck on her journal page. The duck story allowed Deana to
recontextualize the new variables in an imaginary world where she could relate the process of dissolving to her own experiences and emotional responses, such as not liking messiness.

Although the kindergartners primarily drew on their own imaginary worlds in the construction of science understandings, some children contextualized their understandings with reference to both their experienced and investigative worlds. Nicholas, for example, drew a petri dish and an eyedropper that he labeled “i” (Figure 3). His teacher had used a petri dish and food coloring in a previous classroom science experience during which she added food coloring to water to demonstrate diffusion. Like his earlier contribution to the whole group discussion, Nicholas’s journal entry for the dissolving activity continued to reflect elements of his experience with the previous diffusion activity. This combined his experienced and investigative worlds, but resulted in an equation of diffusion with dissolving. After completing his journal entry, he described his page as follows: “Here’s a bowl?” he said. “And the food coloring from an eyedropper is dissolving and that’s why I put a ’d’ here.” Nicholas’s use of graphics and his use of the word “dissolving” demonstrated the link he had made between two experiences that were perceptually similar.

Jeffrey, on the other hand, contextualized his journal response completely in the world of the investigation at hand, creating his own version of the teacher-provided data table he had completed during the first portion of the dissolving activity (His chart is shown in Figure 4). Although Jeffrey found the results of the sugar, sand, and salt tests uninteresting, he was intrigued by the reaction of his soil sample, which contained some small pebbles. Inventing his own scientific term, he explained: “The dirt is fracturing. Some parts of it are on top and some

Figure 2. Deana’s duck story.
are on the bottom. It’s different from dissolving.” To reflect his observation that the soil did not dissolve completely, he recorded “dirt” as a non-dissolving substance. Jeffrey’s original term “fracturing” reflected his understanding of a middle ground between dissolving and not dissolving. This perceptual distinction was based on the fact that some pebbles found in his soil sample did not dissolve while the soil itself did; thus the soil sample appeared to “fracture” or break when he added water. Jeffrey’s perception of the phenomenon and his language use contributed to his journal entry, which reflected the world, or frame, of the investigation itself. This contrasts with Deana, who invented a story to contextualize her understanding of dissolving, and with Nicholas’s relation of dissolving to a previous experience.

Fourth Grade. The fourth grade class engaged in a unit about sound that lasted 2 weeks. During the first week the children explored the phenomenon of pitch and applied these understandings to the construction of musical instruments during the second week of the unit. Only the first week of activity is reported here. The children used their science journals in three different instructional contexts: (1) to explore their prior knowledge about sound; (2) to make
predictions based on a teacher demonstration; and (3) to document small-group investigations of rubberband pitch.

At the fourth-grade level, the imaginary world was less influential than in the kindergarten. The fourth-grade children seemed to focus their attention on the systematic organization of data from the investigative world of the science experience itself. The only exception to this orientation occurred during the teacher’s introduction to the study of sound. For this the teacher first conducted a brainstorming session inviting the class to identify several sounds. Next, the teacher posed two questions: “What is sound?” and “How is sound made?” The children responded to these instructions by writing and drawing in their journals. These entries primarily reflected experiential contexts that were familiar to the children. While some of these responses consisted solely of writing, others combined writing with drawings that detailed ideas in visual terms. For example, in answer to the question, “How is sound made?” Kim drew a girl whose mouth was open; she labeled this drawing with the word “Yeal” (i.e., “yell”). Her accompanying written text expressed two generalizations in answer to the teacher’s questions: (1) sound “... is something you hear,” and (2) sound is made “... when someone douse (sic) or makes one” (Figure 5).

The teacher’s demonstration proceeded as follows; after her introduction, the teacher conducted a two-part demonstration of the variables that affect the level of pitch, which she described as “sound.” First, she described the demonstration materials, consisting of three identical glass bottles filled with different volumes of colored water: red, blue, and green. Before tapping the side of each glass bottle, she asked the children to predict the order of pitch from
highest to lowest and to explain these predictions using either writing, drawing, or both. The teacher then tapped the side of each bottle to demonstrate the difference in pitch while the children checked their predictions. The teacher next presented a discrepant event focusing on the movement of air across the top of each glass bottle (i.e., the vibration of the volume of air vs. the vibration of the volume of water). After describing the procedures, the teacher again asked the children to predict the pitch sequence for the bottles and to explain this in their journals using drawing, writing, or both. When the children had completed their journal entries, the teacher conducted the demonstration followed by a brief sharing of some of the children’s predictions and explanations.

Focusing exclusively on the journal entries, all 20 children in the classroom used both writing and drawing to compose their predictions and explanations. In general, children’s approach to their journal entries depicted the demonstration materials. Most of the children’s entries showed the three glass bottles, each with a different water level (volume), and sometimes the spoon used to tap the bottles. Some children identified the color of the water in each bottle while others indicated the water level by either writing “water” and/or by drawing the water line. All of the children labeled each bottle with a prediction about its relative pitch, but only 50% of the children added any explanatory text. At the end of the demonstration segment the journal served as a forum or tool for only half of the children to explore the reasons for the changes in pitch.

Although the journal entries during the introductory activity reflected a reliance on the children’s experienced worlds to convey their understandings about sound, the journal entries for the demonstration activity focused on the investigative world of the science activity itself. In this case, the demonstration materials pulled the children into the investigative world of science, that is, the materials provided a context that framed the ways in which children came to understand and experience sound in the investigation.

In order to challenge the children’s understandings of pitch the teacher next engaged them in a collaborative investigation of the variables affecting the relative pitch of rubberbands. The teacher began with a guiding question: “What makes the pitch different?” She also reminded the children to write and/or draw in their journals about “their ideas, what they did, and what they found out.” The children then moved to small groups of four at tables. The children had worked together in these small groups prior to the rubberband investigation. Each group was supplied

Figure 5. Kim’s definition of sound.
with a single set of materials, consisting of seven rubberbands of various colors, lengths, and thicknesses, and a ruler; each child had a blank spiral notebook used only as a science journal. For the next 2 days the children in each group designed, conducted, interpreted, and documented their group’s rubberband investigation in their individual journals. The children made these entries as they determined the need to do so throughout the activity.

While the kindergartners’ journal entries reflected a reliance on the imaginary world to make sense of the science investigation, the fourth-graders focused on either the investigative world or a combination of investigative and experienced worlds to make sense of the rubberband

![Kim's data table.](image-url)
investigation. For example, Kim’s data table (Figure 6) grouped the rubberbands according to three criteria: color, size, and pitch. The size category contained two quantifiable dimensions: thickness (measured in millimeters) and length (measured in centimeters). Kim linked each rubberband color to a pitch category using a system that quantified the pitch hierarchy using written labels. This set of labels varied from “V. Low” (i.e., very low) to “V.V.V.V. High” (i.e., very very very very high). Her category set emerged from an understanding of the science phenomenon based solely on the investigative world.

In contrast, Laurie characterized her understanding of the rubberband activity by developing a set of written similes; she also recorded the variables of color and thickness (measured in millimeters). This process enabled her to differentiate the rubberbands by matching the quantitative variables with an element of her experienced world. The blue rubberband sounded “like a bass,” the white like a “guitar string,” and the green like “a smack on the face.” Laurie’s understanding relied on an interplay between the investigative and experienced worlds, reflected in her data table (Figure 7). When asked which of her journal entries helped her to learn the most about sound, Laurie indicated this table, shown in Figure 7. She explained the origin of the similes she used to characterize and differentiate the range of pitches:

Laurie: I did the tables and then I took each rubberband and we measured it. Then the color and then we plucked it and did what it sounded.

Researcher: So... the other side of the line is what it sounded like?

Laurie: Yeah.

In this way, Laurie set up a data table that combined the investigative world with her own experienced world, reflected in her verbal similes. She viewed this as the most valuable way of conveying what she understood through empirical investigation. In fact, over half (12/20) of the children in the class conveyed their understanding of the rubberband pitch differences through some sort of data table. One group of the remaining eight children, however, used data webs as a different format for displaying the same categories as the other children (i.e., color, thickness, and pitch hierarchy). Rachel, a member of this group, also incorporated a set of verbal descriptors linking pitch with vibration. She characterized the pitch of the green rubberband as, “High not much vibration” and the pitch of the thin green (“Thin gr”) rubberband as, “The higher the more vibration.” Like Kim, Rachel’s understanding of the rubberband activity focused on the immediate context of the science investigation itself. Unlike Kim, however, Rachel’s presentation of the data categories in a web format led to a constellation of descriptors which reflected her understanding that rate of vibration determines pitch level: “higher” pitch is caused by “more vibration” as opposed to “High” pitch, caused by “not much vibration” (Figure 8).

The remaining group of four children conveyed their understandings in differing ways on their journal pages. Tom’s two-part entry, for example, reflected his talk with the small group. He began with a categorization of the rubberbands by color and length, followed by a graphic representation of his testing procedure. His categorization chart incorporated the color and length of the rubberbands with length measured in either centimeters or inches (Figure 9).

Michael: What if some stranger walked up and said, “A is big”? How would you know that—what A is?
Teacher: Right.
Tom: You have to do colors!
Michael: Size.
Teacher: Colors and size. How could you measure the size?
Tom: A ruler.
The other children in the small group then pursued tracing the rubberbands as a way of recording relevant distinctions about size, as suggested by Michael and Brandi. Tom ignored this procedure to pursue his chart and measurement process.

Michael: I know what we could do. We could like trace their—trace 'em.
Teacher: Tom has a chart going here and the rest of you have pictures. Okay after you get these pictures drawn, then what are you going to do?
Michael: Label 'em. We're gonna draw these pictures and label them so then we can write like Brandi.

Tom: I’m not doing ABCDEFG.

Tom continued to construct his chart by measuring and recording the lengths of the rubber-bands; however, Michael persisted in presenting his tracing and labeling procedure. Eventually,
in order to follow the group, Tom agreed to trace and label the rubberbands at the bottom of his journal page.

Michael: Here’s what I’m doing. You guys, here’s what I’m doing. This way’s easier because you make how big the rubberband is and then label it, and all you have to do is ABCDEFG, down the table.
Tom: I am going to put that on the bottom part.
Michael: Too bad.
Tom: Okay, I’m going to do my sizes now. Actually I’m going to trace them. Are you guys tracing the inside or outside of them?

Tom then returned to his measuring, never actually using any of the information from the tracing activity. He measured the smallest rubberbands in centimeters because he was unable to interpret the smaller units in inches (e.g., 1/8 or 1/16 of an inch). He represented this measuring procedure by drawing a ruler captioned with, “How I measured it.” He then paired the rubberbands by similar length to test for difference in “the lowest sound” and then the “highest sound” (i.e., pitch) by stretching the rubberband either 13 or 9 cm. He first eliminated rubberbands with a high sound, “h.” Tom also recorded his “pridiction (P),” representing his view of the two possible outcomes, under the diagram of his testing procedure: “(P) Thicker it is less bibration” and “(P) Thinner it is less bibration.” Through his journal entry, then, Tom graphically traced his own process of recording data, making predictions, testing these predictions, and displaying results (Figure 9).

As exemplified above, the fourth graders’ approaches to collecting and recording their data drew on concepts and images from either their experienced worlds, the investigative world of the rubberband activity, or a combination of the two. In all cases, however, the children’s conclusions were confined to statements about the investigative world of the science activity itself—including neither statements about previous experience nor applications of pitch to any outside experience. As a result, the children’s conclusions did not make use of their earlier written or drawn characterizations of sound that were based predominantly on the experienced world. Although the children’s journals showed varied graphic presentations of data, their conclusions were conveyed only in writing. This was the only phase of the activity for which the children did not use drawings or other forms of graphic organization to document their thinking and processes of investigation. Kim’s conclusion, for example, illustrated her immersion in the investigative world with a description of pitch in terms of rubberbands alone, often using abbreviated sentences:

The thickest rubber band makes a more vibration and more pitch. The more you stretch the higher it gets and the thin one the faster vibration and the titer the higher. The lower the sound more it vibrates. The color did not matter.

For the children participating in this study, the manipulative materials of the science investigation served as a vehicle for bringing the most salient elements of the science activity into the highly individualized frame of each child’s journal page. None of the fourth graders incorporated imaginative activity into their journal entries: the reverse of the kindergartners.

Assertion 2. The child’s construction of ideas about a current science experience as expressed on the journal page may reflect experiences with other conventional texts. In this study the children’s representations of their imaginary, experienced and/or investigative worlds were shaped by other texts and structures such as school science texts.
Two characteristics of school science texts are the use of scientific jargon and classification systems (Martin, 1990). In contrast, fictional narratives use invented characters, settings, and events to convey a message (e.g., Applebee, 1978). Although many of the fourth graders drew on school science texts, the kindergartners’ reliance on imaginary worlds led many to depict science understandings using elements of fictional narrative. We first discuss the ways in which the kindergartners used elements of conventional texts and then the ways in which the fourth graders drew on other school texts.

**Kindergarten.** At the beginning of the dissolving activity the teacher provided a data table for the children to record the results of their investigations of sugar, salt, sand, and soil. Jeffrey directly borrowed elements from the form and function of this school science text: formally, he listed each substance used in the activity and connected the results of each test to the substance by using an arrow instead of using columns and rows. Although Jeffrey’s chart varied from the form of the school science text, the function of his journal entry was the same: to categorize the results of his tests (see Figure 4). Interestingly, Jeffrey also invented a jargon-like term (“fracturing”) and attached an original definition to describe his results, mimicking the language of science. More frequently, kindergartners depicted the materials used in this experience or a previous one as in Nicholas’s drawing of a petri dish with an eyedropper. They also borrowed the devices of fictional narrative for their science journal entries. For example, Deana created a story including a duck character in a beach setting. She used drawing, invented spelling, and oral narrative to illustrate what she had taken from the science investigation: in her story, dirt dissolved between the duck’s “toes” (see Figure 2). Young children’s emerging literacy capabilities need not be limited to their use of extended narrative texts as models for the written representations of experience (Martin, 1990). Most of the kindergartners drew or talked about...
aspects of real or imaginary situations to “tell stories” about their understandings. Jeffrey’s table, however, illustrates that forms appropriate to science literacy can be useful for very young children. This requires that teachers model the forms appropriate to different scientific purposes and help children to see how these forms make sense in different situations.

*Fourth Grade.* During the rubberband investigation, the children’s journal entries drew almost exclusively on the forms and functions of other school science texts. For example, Kim constructed a data table that communicated both the quantitative and qualitative variables she had selected as the most salient (see Figure 6). Unlike Jeffrey’s kindergarten journal entry, Kim’s table displayed her data using the conventional form of school science texts: rows and columns. The table’s function was to categorize the data: Kim recorded the length, width, and pitch of each rubberband according to color. The text following her data table resembled that of a school science text: first, it used the language of science—“vibration” and “pitch.” Next, it contained both an interpretation of the pattern she found in the data and an explanation for the data pattern. Both of these functions are conflated in her text, however, unlike more conventional science texts in which the two functions are consigned to separate sections. For example, Kim stated, “The thickest rubber band makes more vibration and more pitch.” This sentence combines interpretation, “thickest rubber band . . . more pitch” with an explanation, “more vibration.” Other sentences in her written text seem to function as attempts at data interpretation, such as the use of “the more . . . the more” clauses to express the relationships found in the data. The problem is that this clause structure does not help Kim to either interpret or explain because it does not mirror an underlying understanding of the causal relationships in the data.

While most children constructed data tables modeled on those from school science texts, others drew on graphic formats that were more common to school language arts texts. Martin (1990) argues that school science textbooks ought to introduce students to the kinds of texts and graphics that reflect the ways in which scientists organize the world. Classification and composition diagrams, for example, are central to the non-narrative writing of science. The purpose of a web style story map, however, is to “…focus on the most important events” so that children do not “get bogged down in details” of a fictional narrative (Temple & Gillet, 1996, p. 192). Rachel constructed a web that depicted each rubberband, using color and size as the organizing characteristics and adding an inconsistent selection of variables that simply described individual rubberbands. In contrast, her written text did relate variables and then distinguished patterns that explained the causes of pitch differences (see Figure 8):

The thin rubber bands had a higher pitch and the thick ones have a lower pitch. The longer it is the higher the pitch is and the shorter it is the lower the pitch is. The thicker it is the less vibration and the thinner it is the more vibration there is.

Although Rachel’s conclusions were valid ones, productive science instruction might now present her with a graphic form that more efficiently categorizes and relates observed details in a scientifically conventional way. This would link science literacy to the child’s existing cognitions developed in the context of a science investigation.

The fourth graders’ journal entries functioned most often as limited “information reports” (Derewianka, 1990, p. 52) or factual statements of results that did not reflect the history of their experimental processes and developing ideas about the pitch of rubberbands. In this sense, the children’s journals “…treat the various experiments, concepts, laws, and theories of the current normal science as separately and as nearly seriatim as possible,” as do many school science texts (Kuhn, 1970, p. 140).
Conclusions and Implications

Children recontextualize (or frame) their understandings of science investigations and phenomena with reference to three types of mental contexts that may be reflected graphically on the pages of their science journals. These contexts are their imaginary, experienced, and investigative worlds. By drawing on these three worlds or internal contexts, the children were able to pull an external phenomenon into an internal context that was familiar to them. This internal context linked with the science phenomenon at hand to frame a way of thinking that used the children’s prior knowledge and experiences to construct science understandings. This way of seeing the world through imaginary, experiential, or investigative sets of lenses shaped the ways in which children’s prior experiences and knowledge were used to understand the immediate science phenomenon and activity.

The classroom situations illustrated here suggest that the role of journals in the science curriculum can be enhanced and elaborated if journals allow children to use various child-selected combinations of writing and drawing to construct and represent their understandings. This approach to journal use allows children the flexibility to explore different genres of writing (e.g., narrative, informative) as well as drawing for a self-selected purpose within the overall structure of the science experience. This enables children to use science journals in ways that are both socially and cognitively appropriate to their developing understandings of science phenomena.

Science journals also provide teachers with opportunities to access the ideas and understandings children have of science phenomena and concepts as well as the literary forms that are familiar to them as tools for expressing meaning. It is important to assess not only what the child knows from prior experience, but also to understand how children use a particular lens to view a classroom science activity. Assessment of science journals may help teachers become aware of the ways in which children’s imaginary, experienced, and/or investigative worlds shape their understandings of science phenomena and concepts. There is a need to understand the ways in which the child’s concept of a phenomenon relates to the particular world that is most salient to that child. This provides an opportunity for the teacher to work with the child to clarify gaps in that understanding and to move from the child’s focal world to other worlds.

National science education standards stress that teacher analysis of children’s journals provides a knowledge base for making decisions about interactions, modification of learning activities, and insight into the design of learning activities “that build from student experience, culture, and prior understandings” (NRC, 1996, p. 42). Effective teachers use multiple methods of assessing students’ performance and understandings and link assessments to learning experiences or activities. Assessing children’s journals fits within the context of Teaching Standard C (NRC, 1996). Children’s self-produced journals link assessment with the learning activity and provide insight into students’ developing understandings. Children’s journals provide written and drawn indicators of their understandings and abilities as well as to the nature of their thinking and the origins of what they know (NRC, 1996, p. 38).

According to the national science education standards, another important aspect of inquiry and science learning is “. . . the oral and written discourse that focuses the attention of students on how they know what they know and how their knowledge connects to larger ideas, other domains, and the world beyond the classroom” (NRC, 1996, p. 36). Teachers of science support students by requiring them to record their work and promote different “forms of communication (e.g., spoken, written, pictorial, graphic, mathematical, and electronic)” (NRC, 1996, p. 36). According to Teaching Standard B, the teacher’s role is to support interactions, listen, encourage
participation, and guide discussion by “...determining ideas to follow, ideas to question, information to provide, and connections to make” (NRC, 1996, p. 36).

For example, a kindergarten teacher might first ascertain that Deana understood dissolving in the context of an imaginary world where dirt dissolved between a duck’s “toes.” In her journal, Deana had indicated that neither sand nor dirt dissolved. Because Deana’s understanding of dissolving is incomplete, the teacher might lead her to rethink the concept by working back and forth between the imaginary world in which the meaning of dissolving originated for Deana and the investigative world. The teacher might introduce the experienced world by helping Deana to wash the dirt off of outdoor toys or shoes. This process might help Deana to revise her findings in her journal. In Deana’s case, the understanding developed in the imaginary world would be equally as powerful as understandings that developed in either the experienced or investigative worlds. It is important to work from the child’s focal world to other worlds in which the child can fully apply scientific understandings, and move from this experience base to the investigative world.

In the science investigation itself, the manipulative materials inserted another level for bringing the most salient elements of the activity into the individualized frame of each child’s journal page. In the kindergarten there was no hierarchy of worlds in which the investigative was more highly valued than the imaginary or experienced worlds in terms of developing a child’s emerging scientific literacy. In the fourth grade, however, an implicit hierarchy did exist in which the children confined their thinking and their graphics to the investigative world. The fourth graders did not go beyond descriptions of investigations and recall to either explanation or application. We speculate that many of the children’s previous science experiences were confined to following directions in order to complete a procedure and/or to simply recording observed results. This limitation was compounded by the fact that the teacher’s talk in this experience focused on simply carrying out the experiment and did not provide a link back to the demonstration in which she had probed for explanatory comments. Effective science teaching requires an ability to distinguish reportage from explanation and interpretation in both the oral and written discourse of school science situations.

Martin (1990) argues that the teaching of writing for science purposes should not emphasize fictional narrative. Imaginary and experienced world entries, however, can show a teacher the links that children are making between science experiences and other contexts. Some of these may be accurate but idiosyncratic while others may be erroneous. Imaginary and experienced world entries may contain information or evidence understandings that suggest modeling the use of a data table, for example. In this way, conventional science genres can be mapped onto existing understands. This requires that teachers become familiar with the forms of scientific writing so that they can model the forms appropriate to different scientific purposes. This must be based on teachers’ own knowledge of science so that children can see how the use of the forms of scientific literacy make sense in different situations.

Although this initial research provides some insight into children’s representation of their science understandings on the journal page, many questions remain:

- What kinds of instructional strategies would enable teachers to structure science experiences using journals to promote and build a complementary relationship between children’s use of their imaginary, experienced, and/or investigative worlds?
- How does the integration of children’s investigative, experienced, and imaginary worlds influence the graphic representation, interpretation, and final understanding of the science activity at hand?
- How do social interactions influence both children’s use of journals and their construction of science understanding?
Finally, how can teachers utilize these interactions as well as children’s journal representations to assess progress in the development of scientific understanding?

The research reported here presents one portion of a larger picture in which journals can show us some of the particular ways in which children connect the visible activity and materials of science with the invisible internal worlds that are already familiar to them as ways of understanding.

References


