The Use of Historical Materials in Elementary Science Classrooms

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ABSTRACT: Science educators have stressed in recent years the importance of providing students with an historical understanding of the development of scientific knowledge. Although many approaches have been suggested for building historical understanding of science, historical source materials have often been deemed too difficult to use with elementary school students. This article reports on a case study that used archival and contemporary source materials in project activities, such as photographs and field notes, to engage students in the processes of data generation, selection, annotation, and evaluation. The curricular science activities of one elementary classroom with 29 fourth and fifth grade students are decribed and analyzed as they build and use archives of historical and contemporary naturalist materials. The article concludes with a discussion of the feasibility and benefits of using historical source materials within elementary science education, as well as the implications for selecting and preparing historical source materials in digital format for use in elementary education. *Sci Ed* **85:**349–367, 2001.

INTRODUCTION

Science educators have repeatedly stressed the crucial role that knowledge of scientific history plays in building a foundation for scientific literacy (Duschl, 1985; Matthews, 1994; Wandersee, 1992). Students need to understand not only the key concepts and principles of science, and how scientific knowledge is applied, but also the cultural and social contexts within which science is advanced. Indeed, many educators and researchers have made the point that seeing science as part of the larger social and technological fabric is an essential part of scientific literacy (e.g., Bybee et al., 1991). For these reasons, the integration of history and philosophy into science curricula has been promoted by national standards and several state frameworks (e.g., California State Framework, 1996; National Research Council, 1996).

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While many approaches have been advocated for how such an integration might take place—such as portraying famous scientists and engineers (Solomon, 1991), presenting critical incidents in the form of vignettes (Wandersee, 1991), or emulating critical experiments and developments (Klopfer, 1963)—the use of historical materials themselves has been less prominent partially because of their lack of physical and intellectual accessibility for young students. Many researchers (e.g., Carey, 1985; Driver et al., 1985) have documented developmental constraints in children's understanding of science concepts and conducting of science activities. In contrast, however, Metz (1995) has argued that, with the use of strategic scaffolds and carefully chosen activities, even young students could participate in the learning of science deemed previously too difficult for them. Under such premises, selected well-contextualized historical materials could be integrated into the science activities of elementary students.

This article reports on the selection and integration of one type of historical material, archival primary sources, into elementary science learning activities. Archival primary sources mainly comprise unique and unpublished materials, such as official records, manuscripts, scientific documentation, still and moving images, and oral histories. They are preserved by repositories such as archives, historical societies, and library special collections in the form in which they were originally created, maintained, and used. In the research described in this article, we were interested in examining the proposition that archival practices of selection, documentation, and preservation of primary source materials based on an understanding of the context in which they originated overlap with, and are in many ways akin to, the scientific practices of recording scientific data, documenting experiments, and presenting results. As a result, engaging students in documentary practices with contemporary and historical primary sources can constitute a compelling context for investigating scientific practices and concerns over time.

In a case study designed to explore this proposition, we employed a combined approach in a fourth and fifth grade science classroom using documentation created by an early-twentieth century naturalist, Donald Ryder Dickey, in the course of his fieldwork in Southern California and preserved in a local archival repository. The Donald Ryder Dickey Collection consists of an archive of over 7000 photographs, 50,000 specimens, and numerous field notes created by Dickey and his collaborators. For the case study, part of this collection was selected and digitized by the researchers, in consultation with both the teacher and the archivist responsible for the Dickey Collection, and made available in a digital archive to the students over the World Wide Web. The students visited the archival repository that held the complete original archival collection and also accessed the Web-based archive containing the digitized copies of the archival materials selected for classroom use.

The students' work with the archival materials was situated within the context of taking a field trip into a local nature preserve. They documented their observations of the contemporary Southern California landscape, flora, and fauna through the creation of their own primary sources in the form of field notes and photographs. Students then selected from and documented these field notes and photographs in order to create their own archives, which they then also compared with the digital archival materials.

The key activities described in this article center around students' efforts to create, describe, evaluate, and select from the contemporary primary source materials and analyze and compare them with the historical materials. In our discussion, we address selection and scaffolding issues associated with introducing and using historical source materials in elementary science education. We conclude with a discussion of the implications for selecting and preparing historical source materials in digital format for educational purposes.

BACKGROUND

Many reform efforts, such as Project 2061 by the American Association for the Advancement of Science (AAAS, 1989), *Science for All Americans* (Rutherford & Ahlgren, 1990), and the National Science Standards (National Research Council, 1995) have stressed that historical knowledge should be an important component of scientific literacy. Yet, on a practical level, most teachers address this emphasis by merely introducing a unit drawing upon historical background and then moving on to cover current materials (e.g., Wandersee, 1985). Rather than pedagogically integrating the history of science, these efforts often merely juxtapose it with the contemporary concepts and processes to be learned and, therefore, do not engage students in critical examination of how scientific ideas and processes are developed.

As Matthews (1994) has documented, however, a considerable number of pedagogical approaches and curricular designs have been developed that integrate the sociohistorical understanding of science. Klopfer (1969) distinguished between four different approaches: the study of historical cases in which students would follow the evolution of major scientific ideas in detail; the reading of biographies coupled with class discussions; the study of historical (i.e., original) papers; and the historical curriculum sequence in which curriculum units themselves would mirror the historical development of ideas. The Harvard case studies have been one of the most well-known and successful implementations that restructured undergraduate students' introduction to physics so that it was taught from an historical perspective (Klopfer & Cooley, 1963).

While researchers agree on the general importance of providing a historical perspective, the specific approaches have been subject to debate, in particular, the portrayal of the history of science (e.g., Brush, 1974; Russell, 1981; Siegel, 1979). The observed discrepancies between the historical record of science and its portrayal in textbooks have concerned some science educators. They raised the issue of whether students' views of science might be influenced in distorted ways. Another issue has been the intellectual accessibility of historical materials. Developmental constraints in young children's reasoning have been seen as an obstacle to introducing many science activities at the elementary school level (e.g., Carey, 1985; Driver et al., 1985). Moreover, these repositories are often restrictive in the ways in which users are permitted to interact with the materials and in the kinds of intellectual assistance (such as developmentally appropriate descriptions of the collection) that they provide for young students. In addition, the unique and often fragile nature of these materials generally requires that students must visit the physical repositories in order to work with them—an immediate limitation for classroom use. For these reasons, most curricular approaches to the history of science education have been limited to high school and college students.

If historical source materials have been used with younger students, curricular developments have included synthesized or secondary historical source materials, such as biographies, vignettes, and case studies and occasionally primary historical source materials such as feature photographs, newspaper clippings, or notebook entries. One approach has been to use biographies of famous scientists to propagate models such as "scientist as hero." This approach can add a personal element to science which is often lacking (Solomon, 1991). Similarly, drama and role playing enable students to reenact dramatic moments in scientific discovery. Wandersee (1992) proposed the use of "historical vignettes" that represent brief dramatic incidents in the life of famous scientists whose work is relevant to the course material taught. These vignettes then serve as a starting point for further classroom discussion. Another example is an electronic discussion forum for reenacting debates around scientific issues (Bell & Linn, in press).

These approaches provide access to the history of science by preparing and editing primary sources, or as Metz (1995) has suggested, by using *contextualized* and *scaffolded* activities so that even young children can be introduced to challenging scientific inquiries. In line with Metz's recommendations, we sought to create an appropriate and scaffolded context to support young children's engagement with primary sources. We did so by choosing an archival collection that contained intellectually accessible materials, focusing on naturalist activities within an archival context, and creating support structures that would facilitate children's emulating scientific and archival practice.

We chose a field trip to one of the few remaining wetland preserves in the Los Angeles metropolitan area as the focal point of the project and asked students to document the landscape, flora, and fauna in photographs and field notes. Although many classes make field trips to study local surroundings, few of them have the opportunity to examine their findings and observations within an historical context to understand potential implications of change over time. Before the field trip, we introduced students to the life of Donald R. Dickey by visiting the repository where the collection is held and studying his biography and examples drawn from the collection. We explained to students that whatever information a naturalist collects, be it in the form of field notes, photographs, or specimens, there is a need to document the collection process, to make evaluations and selections of what to preserve for subsequent analysis, and then to arrange and describe that documentation. Students were then asked as part of the field trip to emulate Dickey's naturalistic activities by documenting landscape, flora, and fauna for the purposes of research and posterity.

The purpose of our research was to examine not only students' use and understanding of existing primary sources from the Dickey collection, but also how students went about creating, selecting, and documenting their own primary sources. We were interested in students' abilities to consciously create and document their own primary sources in ways that might subsequently be used by others, just as they were today using documentation created by Dickey nearly 80 years ago. We also assessed what elementary students could learn from engaging with primary sources to further their understanding of scientific inquiry.

RESEARCH METHODS

Research Context

The research took place in one integrated fourth and fifth grade classroom in a local urban elementary school associated with the University of California, Los Angeles. The school houses about 450 students ranging from pre-kindergarten to sixth grade. The participating classroom was equipped with six computers aligned along two classroom walls, plus an additional four computers in an adjoining shared work room used for individual tutoring or small group activities. The computers are Macintosh workstations installed with commercial word-processing and spreadsheet software and Netscape's Internet browser, version 3.01.

Research Participants

A class of 29 students and their science teacher participated in the study. The class had 17 boys and 12 girls with ethnic backgrounds representative of the distribution found in the state of California: 47% of the students are Caucasian, 19% are Hispanic, 12% are Asian, 14% are African American, and 8% are of mixed background. All of the students

used computers as part of other classroom activities, such as word processing and Internet searching, or with specifically selected educational software. Neither the teacher nor the students had any prior experience in working with primary sources in science learning activities.

Research Archive

Naturalist Donald R. Dickey created his archive during extensive fieldwork in Canada; Hawaii; Laysan Island, California; and Baja, California between 1908 and 1923. Dickey photographed wildlife, habitats, and general landscapes; built a collection of taxidermied specimens; and kept extensive field notebooks together with topographical maps. The Dickey Collection is of particular significance not only because Dickey's work was extensively published in journals such as the *National Geographic*, but also because his work documents Southern California before the post-World War II population explosion forever altered the landscape of its flora and fauna. Moreover, the collection has been retained and described in the archival finding aid according to Dickey's own classification scheme, thereby giving considerable insight into his practices of arrangement and description. We felt that these aspects of the collection would help students to learn about and replicate the work of naturalists. The collection would also provide an opportunity for the teacher and students to think about how the work of naturalists has changed over time.

Furthermore, a variety of supporting primary and secondary materials are available. Dickey's collection of wildlife specimens are available in the UCLA Biomedical Building for examination by school field trips, and his handwritten field notes were transcribed and are available in published form through the Smithsonian. Dickey's work can also be compared with published accounts of other early United States naturalists, such as John Muir, and with the work of contemporary naturalists. Such additional materials were incorporated into classroom activities, for example, by asking students to read a special historical issue about naturalists published in *Cobblestone*, a magazine for young readers. The local relevance and uniqueness of the collection, especially from the perspective of ecology and environmental awareness, was another advantage. A large part of the collection relates to Southern California and includes documentation of many areas with which students are familiar and to which they might take field trips.

Finally, the visual content of the collection was important. The collection contained a large number of black and white images, including glass slides and nitrate negatives, which capture considerable amounts of contemporary detail of the environment and naturalists' life in the field. Both the form and the content of these images also function as historical artifacts, however, that can reinforce in students the development of a sense of the passage of time in terms of changes in naturalistic practices and recording technology as well as changes in the recorded environment.

Classroom Activities

The project started with planning meetings in which the teacher and researchers met to discuss classroom activities and how to introduce and integrate the historical materials. During these meetings, the teacher suggested the field trip and visit to the Dickey Collection to contextualize the documentary activities for the students. Furthermore, the teacher and researchers reviewed together all the student materials, provided supplemental readings such as the *Cobblestone* article, and reviewed and elaborated upon the descriptive elements that were to be used by students to describe their own photographs. In conjunction with the classroom preparations, the teacher also met with the archivist responsible for the

Dickey collection to help select photographic and field note materials for classroom use. These materials were digitized by the researchers and individually described using the same data elements that the students were to use in their classroom activities.

The project lasted approximately 2 weeks and was divided into three phases: archive creation, analysis, and comparison. One researcher (and occasionally other members of the research team) was present during all of the classroom activities.

Archive Creation. Students were introduced to the idea of naturalist research and archival activities by learning about the life of Donald R. Dickey through biographical elements and contemporary photographs. Furthermore, the class viewed excerpts from a film documenting Los Angeles and Southern California landscape and development around the turn of the century (Margaret Lesser Bach, 1975, "Landscape with Angels"). Teams with two to three students (assignments were made in advance by the classroom teacher) received notebooks in which to keep their notes and information materials about the field trips, as well as disposable cameras. On the following day, students visited the archival repository that houses part of the original Donald R. Dickey Collection. The archivist displayed a number of different items, such as original glass and plastic negatives, index cards accompanying the photos, field notebooks, and two stuffed birds drawn from the Dickey Collection. Students were able to examine and physically touch items, read passages from the field notebooks, and ask questions. Students then examined the filing cabinets and shelves in which the extensive photographic negatives, notebooks, and index cards were stored. At the end of the day, each team took a picture of all its team members and filled out a description sheet.

The description sheets contained nine categories of descriptive information which students were asked to complete for each photograph they took (see Table 1). We explained to students that these categories are used by information creators and archivists to label and describe their materials. Each category was labeled and some contained additional parenthetical information supplied at the request of the teacher in order to give students more help in determining how the categories would be used. These categories were chosen because they corresponded to descriptors, called Dublin Core Elements, that have recently been developed by a coalition of library, archives, museum, and Internet interests to provide a simple, but core description of digital resources (Dempsey & Weibel, 1996). These data elements, therefore, provided a minimal, yet systematic set of categories to describe items found in both the Web archive of Dickey materials and the students' own materials.

TABLE 1
Descriptors Mapped to Dublin Core Elements

Description/Annotation Descriptors	Dublin Core Elements
Picture number	Identifier
Date (picture was taken on)	Date
Source (describe the place where you took the picture)	Source
Author (picture taken by)	Author
Who else? (people who helped taking the picture)	Author
Relation to other pictures (say if this picture has any other pictures related to it)	Relation
Subject category (plant/animal/landscape/other)	Subject
Title of this picture	Title

Figure 1. Student photograph of the creek at Ballona Wetlands.

The next day was dedicated to a visit to the Ballona Wetlands. The wetlands are located within a 40-min bus ride from the school. They are surrounded by housing, roads, and the yacht harbor of adjacent Marina del Rey. All the students were asked to document the landscape and its flora and fauna in pictures and field notes. For that purpose, each team had its disposable camera and was also given a clipboard for note taking and a log sheet that would list the numbers and titles of all photographs taken. Before the class left the school, the purpose of the description and field note sheets was reviewed with the students.

Students met with a guide of the Friends of the Ballona Wetlands, a local activist group that organizes tours through the wetlands. The guide introduced himself by having students read observations he had recorded earlier that morning in his personal field notebook. After that, the group set out into the wetlands, each team member carrying a pair of binoculars given to them by the Friends of the Ballona Wetlands. Each team was given the choice of how to distribute their note and picture taking tasks: some teams decided to rotate the camera with every photograph, while other teams divided up the 26 available photographs evenly and rotated the camera after each team member had taken their allotted number of photographs. Inspired by the guide's example, some students also volunteered to take field

Figure 2. Student photograph of the flora of Ballona Wetlands.

Figure 3. Student photograph of adjacent housing to the Ballona Wetlands.

notes while the guide pointed out and explained local animals and fauna. Students took photographs at various time points, although the majority of photographs were taken toward the end of the 2-h tour (see Figures 1, 2, and 3). A lunch break was organized at a local recreational area before the bus headed back to the school. All of the cameras were collected and taken for photographic development by the researchers.

During the fourth project day, student teams received all of their developed photographs in duplicate and were asked to match each picture with its accompanying description sheet and complete any missing information. The photographs were then numbered and one set was clipped to the description sheet, while the other was prepared for digitization. All teams were asked to select those photographs they wanted to be included in their digital archive and to list the reasons why they chose to exclude each of the others. After the completion of this activity, which took some teams more than 1 h because the number of photographs taken varied, all sheets were returned to the team's field notebook. Each notebook, therefore, constituted a team's physical archive documenting the Ballona Wetlands. All students then read a short biographical essay about the American naturalist John Muir from the *Cobblestone* magazine as part of a homework assignment and discussed similarities and differences between their own approaches and those of Dickey and Muir.

Archive Analysis. On the next project day, students started working with the Web-based archive of Dickey's materials and printed versions of his photographs and field notes. Part of working with archival materials is to arrive at an understanding of why particular items were created and retained as part of a collection, and for that reason, the materials are frequently analyzed collectively. For example, while individual historical photographs can provide some clues about the reason why they were created, additional contextual information can be gleaned by relating these to sequences of photographs and field notes from the same field trip. In an exercise designed to illustrate this point, the students analyzed a photograph of a golden eagle nest at Point Mugu (Figure 4) in order to answer the question: "Why do you think Dickey took this picture?" We also directed students' attention to what could be learned in the present time from this picture by asking them: "What's important about this picture for TODAY? What can you do with the information provided about the picture and in the picture?" Students then read Dickey's accompanying field notes in class,

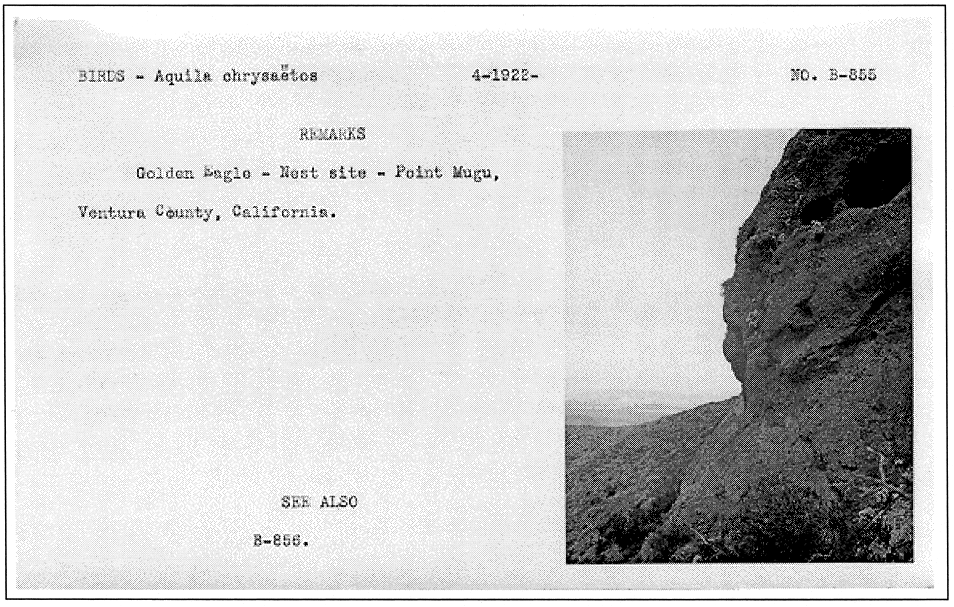


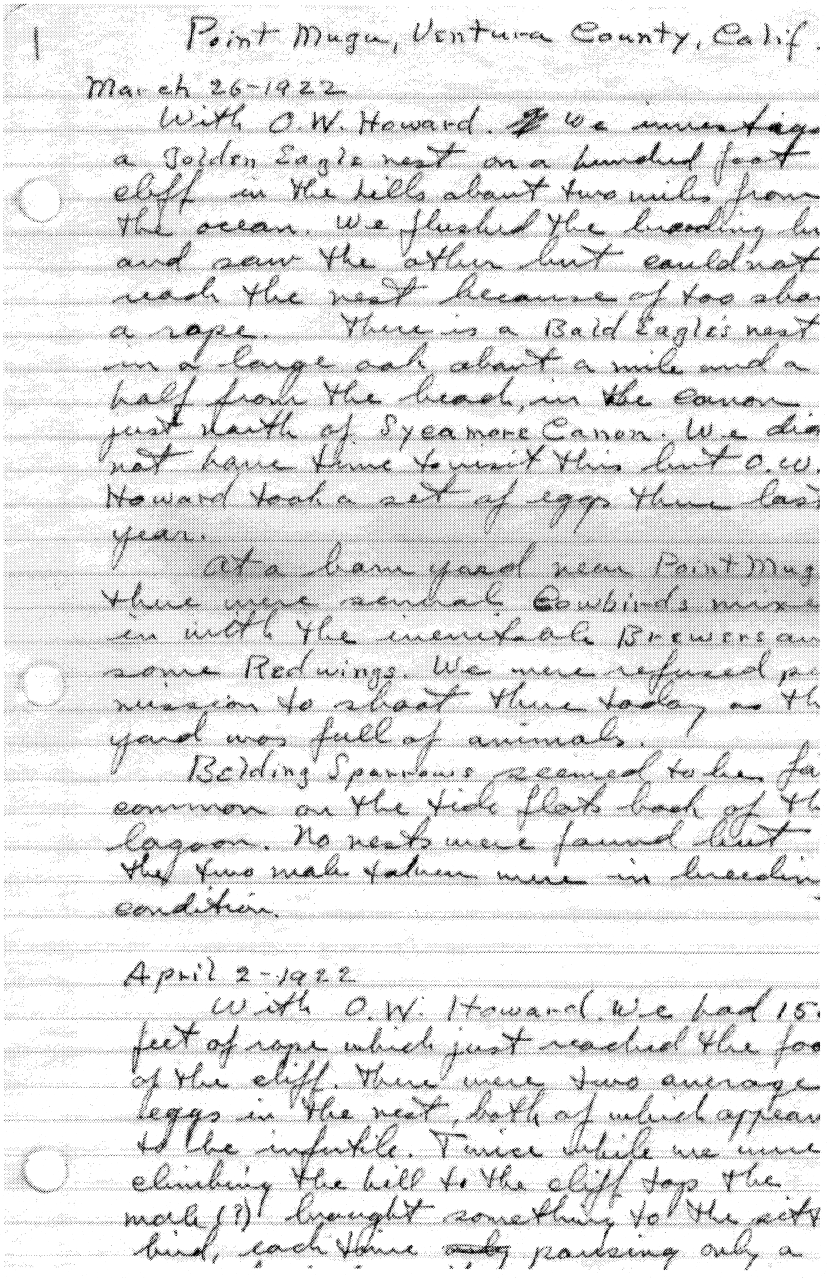
Figure 4. Photograph of Golden Eagle's nest at Point Mugu, Donald Ryder Dickey Collection.

first as a photocopy of the original handwritten field notes (Figure 5), and subsequently in transcribed form (Figure 6). After that, students were asked to look again at the photograph.

Archive Comparison. The researchers created a Web-based digital version of each team's archive with thumbnails of all of their photographs, each linked to a full-sized version of the same picture. Students then compared and contrasted their digital archive with the Web-based archive of selected Dickey materials. In this context, we asked students to compare the historical photographs of the Dickey archive with the contemporary photographs of their own archive. We concluded the project with a "quickwrite activity" in which students evaluated their experiences working with primary source materials, both original and digital.

Research Instruments and Analyses

For the analyses of the student activities and team notebooks, the researchers established coding categories based on the student answers. In some instances, not all students had participated in all activities either because they were not present on all days or they did not participate in field trips, resulting in some missing data. To ensure consistency in encoding, two independent coders then went through all the materials and coded students' answers. The percentage of same codings ranged from 73 to 100% across categories with an average agreement of 90%. Cases in which there were divergences were discussed individually between the two coders and all differences were resolved. This resulted in a single data set that was used for the presentation of results. The individual coding categories for students' answers are explained in more detail in the following section with the results of each activity.


Point Mugu, Ventura County, Calif.
March 26-1922
With O. W. Howard. We inspected
a Golden Eagle's nest on a hundred foot
cliff in the hills about two miles from
the ocean. We flushed the breeding bird
and saw the other but could not
reach the nest because of too short
a rope. There is a Bald Eagle's nest
on a large oak about a mile and a
half from the beach, in the canon
just south of Sycamore Canon. We did
not have time to visit this but O. W.
Howard took a set of eggs there last
year.
At a barn yard near Point Mugu
there were several Cowbirds mixed
in with the innumerable Brewers and
some Redwings. We were refused per-
mission to shoot there today as the
yard was full of animals.
Bedding Sparrows seemed to be fairly
common on the tide flats back of the
lagoon. No nests were found but
the two male taken were in breeding
condition.

April 2-1922
With O. W. Howard. We had 150
feet of rope which just reached the foot
of the cliff. There were two average
eggs in the nest, both of which appeared
to be infertile. Twice while we were
climbing the hill to the cliff tops the
male (?) brought something to the sitting
bird, each time only rearising only a

Figure 5. Sample of Donald Ryder Dickey's field notes regarding field trips to a Golden Eagle's nest at Point Mugu, March 26, 1922 and April 1, 1922.

RESULTS

Archive Creation

While all of the student teams took photographs, none of them used the whole roll of 27 pictures, with an average of 13 pictures per team (see Table 2). The photographs were

March 26, 1922

With O. W. Howard. We investigated a Golden Eagle nest on a hundred foot cliff in the hills about two miles from the ocean. We flushed the brooding bird and saw the other but could not reach the nest because of too short a rope. There is a Bald Eagle's nest in a large oak about a mile and a half from the beach in the canon just north of Sycamore Canon. We did not have time to visit this but O. W. Howard took a set of eggs there last year.

At a barn yard near Point Mugu there were several Cowbirds mixed in with the inevitable Brewers and some Redwings. We were refused permission to shoot there today as the yard was full of animals.

Belding Sparrows seemed to be fairly common on the tide flats back of the lagoon. No nests were found but the two male (Transcriber Note: unreadable word here) were in breeding condition.

April 2, 1922

With O. W. Howard. We had 150 feet of rope which just reached the foot of the cliff. There were two average eggs in the nest, both of which appeared to be infertile. Twice while we were climbing the hill to the cliff top the male (?) brought something to the sitting bird, each time pausing only a second at the nest.

From the top of the cliff we could see a marshy willow grown area at the foot of the hills near Point Mugu. We canvassed this area thoroughly in the hope of a pair of White-tailed Kites or Red-billed Hawks. However neither species was found. There were about twenty pairs of Crows nesting in scattered groups of three or four pairs. There were probably eggs in most of the nests as birds were flushed from several. One of which I climbed held three eggs - probably an incomplete set.

Investigation of a tule grown log at one end showed numerous Redwings present, a few of which were paired off. All of the very few males seen had mates but there were large flocks composed entirely of females. Five or six Bitterns (lentiginosus) were flushed but we could find no nests. There were about a dozen pairs of Cinnamon Teal here and one pair of Mallards was seen flying over. The owner of a nearby ranch told me that he had seen young ducks this year but the date seems very early and he may have been mistaken. There were several pairs of Coots present of course.

Howard flushed three single Wilson Snipes from meadow grass but they did not seem interested in any particular spot and were probably only migrants.

Flushed a Marsh Hawk from a nest with six eggs. It was placed on a mat of broken down dead tules and was without concealment. Both of the parents were extraordinarily pale. The male which at no time came within a hundred yards appeared to be almost white except for the black primarius. The female was taken as she left the nest. Except for her large size she might be mistaken in flight for a rather dull-colored male.

Figure 6. Typed transcription of Donald Ryder Dickey's field notes regarding field trips to a Golden Eagle's nest at Point Mugu, March 26, 1922 and April 1, 1922.

primarily of landscapes (and the creek in the wetlands in particular), animals, and plants seen on the field trip.

In the first round of analysis, all the descriptions and annotations provided by each team for each photograph were analyzed to ascertain whether they were accurate and complete. Each descriptive element was coded as "complete" when students filled it in, and "accurate" when it was filled in appropriately for the category. For some elements, students

TABLE 2
Number of Photographs for Each Team

	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	Team 9
Number of photographs	18	6	12	11	18	12	n/a	11	13

Note. Team 7 photographs and descriptions had to be excluded from the analysis because all the descriptions and annotations were done by an accompanying parent instead of the student team members themselves.

were given categories of terms to be assigned. For example, when a photograph depicted the creek, then the "subject" element should indicate "landscape" as the appropriate term for its completion. For other descriptive elements, it was up to the students to determine how the elements should be completed. The analysis of these descriptions indicates that these elementary students were able to provide in a fairly consistent manner accurate and complete descriptions (see Table 3) for the majority of the elements, including picture number, date, author, subject, and title.

Elements such as source, relationship to other pictures, and picture were left incomplete, however, in many instances. The annotator element asking students to "describe in detail why you took the picture" was also left blank by half of the students. In this case, any responses containing descriptive information about the photograph rather than information about why team members chose to take it were classified as inaccurate for the overall descriptive statistics. Some examples of responses that contain information about why the picture was taken were "it was going over a river and it looked nice" (for a photograph of old trolley tracks crossing the wetlands) and "we liked the way the water looked, we thought it was neat that it had a mini forest in it" (for a photograph of dense plant growth underwater in a shallow area of the wetlands). While students might have left out some information because of an oversight, it is also likely that in some cases students simply did not understand what they were supposed to do with these particular categories.

The ability to provide accurate and complete descriptions is an important aspect of any documentary practice. One component of this ability is being able to create progressively more detailed descriptions (i.e., descriptions which proceed from broad categorization to increased levels of detail). To gain some insight into the students' abilities in this respect, the sequence of related, but progressively granular descriptive categories (i.e., *subject category*, *title of this picture*, and *picture*) were examined in more detail (see Table 4).

The analysis indicated that the subject category was accurately described in over 93% of all photographs, but that a combination of this accurate subject description and a title that provided additional description occurred only in 64% of all photographs. The highly differentiated description—an accurate subject category, a more descriptive title, and a detailed description of the picture—was given in only 38% of all photographs. The num-

TABLE 3
Accuracy and Completeness of Descriptors and Annotation for Each Photograph

$n = 101$	Accurate (%)	Inaccurate (%)	Blank (%)
Descriptors	Total	Total	Total
Picture number	93	1	7
Date	81	0	19
Source	76	1	23
Author	88	0	12
Relation to other pict.	59	1	40
Subject category	96	1	3
Title of this picture	91	0	9
Picture	80	1	19
Annotator			
Describe in detail why you took this picture	38	9	53

TABLE 4
Progressively Detailed Descriptions

	I: % of *n* Assigned an Accurate Subject Description by Team Members	II: % of *n* Assigned an Accurate Subject Description and Then Given a More Descriptive Title	III: % of *n* Assigned an Accurate Subject Description, Given a More Descriptive Title and Then Given a More Detailed Description of What the Picture Was
Team 1 ($n = 18$)	88.9	0.0	0.0
Team 2 ($n = 6$)	100.0	33.3	33.3
Team 3 ($n = 12$)	58.3	58.3	0.0
Team 4 ($n = 11$)	100.0	100.0	27.3
Team 5 ($n = 18$)	100.0	38.9	16.7
Team 6 ($n = 12$)	100.0	100.0	100.0
Team 8 ($n = 11$)	100.0	100.0	72.7
Team 9 ($n = 13$)	100.0	84.6	61.5
Average	93.4	64.4	38.9

Note. Team 7 photographs and descriptions had to be excluded from the analysis because all the descriptions and annotations were done by an accompanying parent instead of the student team members themselves.

bers in Table 4 point out that fewer students were able to provide more detailed descriptions. Although students understood what each category meant (as indicated by results in Column I and in Table 3), they appeared to have more problems in distinguishing between them. Indeed, some student teams completed all three elements in the same way, even though each category is designed to describe the resource being described from a different perspective.

After student teams had completed the description and annotation of all of their photographs, the photographs were reviewed for selective inclusion in the team's digital archive. Each team was asked to record the reasons for their exclusion of particular photographs on their description/annotation sheets. Out of the 101 available photographs, 80% were selected. Team members gave a variety of reasons for excluding pictures from their digital archive. The category "Information value" was selected most frequently in 7% of all cases and summarized student perceptions that the intended subject of their photograph did not show up as well as they had hoped it would. Examples of student responses were "because the thing we're trying to show only showed a dot," "because you can't see the Snowy Egret," and "can berly [sic] see it." Technical problems were selected in 6% of the cases and were related to the use of the camera or unintended problems with picture taking such as "because it's too blurry," "mess[ed] up," and "finger in picture."

Subjective criteria (6%) indicate reasons for exclusion that have less to do with the information in the picture itself, but mainly concern either subjective assessments of the photographs, or students excluding pictures from their digital archive because the picture does not fit their conception of what a naturalist should be photographing. Examples from student responses include "doesn't look good," "because it shows the city," and "because there are people in the picture."

Archive Evaluation

In the archive creation process, we asked students to provide us with rationales for why they had taken each photograph. In the archive analysis component, we asked students to identify Dickey's rationales and purposes in taking photographs. In a first step, students examined a photograph of a golden eagle nest at Point Mugu (see Figure 1). We found that the majority of student responses attributed the bird (95%), the nest (63%), or the location (42%) as Dickey's rationale for taking the photograph. Ten percent of the responses referred to the subject of the picture being rare or endangered. Lastly, 5% of the students gave responses which referred to the picture itself without mentioning content, such as "because he thought it was beautiful." These results indicate that the students were able to identify appropriate rationales as to why photographs had been taken for naturalistic purposes.

When students were asked to speculate about the present day value of the photograph, the majority of responses (94%) focused on "bird" for reasons such as: "This picture is important today because the golden eagle is a rare and important bird to the U.S.A." Seventy percent of students listed comparative reasons which would allow a "then versus now" type of comparison, such as "to see if the nest is still there or has been destroyed." Nests, habitats, and the terrain or location where the animal lived were listed in 55% of answers; for example, "because in this picture it shows a scientist where the golden eagle can live." The code "historical only," given in 10% of answers, referred to responses mentioning how the site looked contemporaneously without reference to the present day implications; for example, "they wanted to see what things looked like back then." Another 10% of the students referred to the ability to find out more about Dickey by looking at the photograph; for example, "the picture is important because he took it. You could do a report on him and the pictures he took."

Researchers such as Scardamalia and Bereiter (1986) have pointed out the importance of students developing questions for further scientific inquiry. After evaluating the photograph and reading the fieldnotes, therefore, students were asked to look again at the photograph and answer the following question: "Having read Dickey's field notes and seen the photograph B-855, what questions do you have for Dickey?" Over 32% of the questions generated by the students focused on personal information relating to Dickey himself rather than to the specific occupation of naturalist. For example, "Do you have kids? What is your favorite bird? Do you like kids?" These questions indicated students' strong personalized perspective view on Dickey's work. Eighteen percent of the questions were seeking additional information, such as "Did the birds come back? Did you see the eggs crack?" The same percentage of questions pertained to differences from one time period to another; for example, "Have things changed since your last visit to the nest?"

Fewer questions (about 13%) referred to the motivations a naturalist might have for taking a picture. For example, one student asked, "Did you take the picture for research or for fun?" Dickey's descriptions in his field notes of killing animals and taking eggs were criticized or questioned by many students. One student asked, "Why did he kill animals like he cuts animals in half?" This resulted in a classroom discussion relating to

the differences between contemporary and earlier naturalist practices. While not all the questions raised by the students were of this nature, many of them, such as wishing to ask Dickey whether changes had occurred at a site between his visits, indicated a desire to learn more about Dickey's work as a naturalist.

Archive Comparison

Students also compared their own photographs with those of Dickey. Over 43% related to indicators of the difference in time periods between when the Dickey photographs and the present day photographs of the students were taken; for example, "They rode horses in Dickey pictures." Students (26%) also noted changes in the physical environment, such as, "In Dickey's pictures, there weren't as many buildings as today." These answers are indicators that students used environmental markers to identify change over time. More strikingly, perhaps, the majority of student responses (70%) commented upon the difference between the black and white photography in the Dickey Collection and the color photography of the students. For example, students responded: "they were in color and with color you can see more detail"; "color pictures have a lot more details, you can see the weather in color pictures"; "in color you can see what color the birds, places, people, and more are"; "the colored photos seem more like they are in action"; and "you can better see detail." Students also were sensitive to other aspects that were expressed through color, such as more detail, presence of action, clarity, and weather visibility. Twenty-two percent of student responses related to the skill of the photographer, such as, "Dickey's pictures are more accurate." Four percent of student responses related to the technical aspects of the photography, such as, "He could take pictures better than us because he might have had a zoom lens."

DISCUSSION

In this case study, a class of 29 students and their teacher participated in various documentary practices that centered around the use of an historical archive and their own contemporary archive. The general proposition underlying our study was that engaging students in documentary practices with historical primary sources can constitute a compelling context for learning about scientific practices and concerns over time. Although documentary activities might not readily come to mind when thinking of the prototypical work of a scientist, there is ample historical evidence, for example, in Charles Darwin's travel logs, of their importance for scientific theory and process. In these documentary practices, the activities of a scientist and those of an archivist are similar and often even intersect. As pointed out already, archival practices focus on the selection, documentation, and evaluation of the primary sources and the context in which they originated and, thus, often parallel and certainly amplify the scientific processes and historical context through which those materials were created and organized. The most important aspect of our case study was that students re-created the process of generating and describing scientific documentation by emulating the activities of an early naturalist. In the following sections, we will examine the feasibility of using historical sources in elementary science classrooms, and revisit benefits and issues of this approach.

Feasibility of Using Historical Materials in Elementary Science Education

Our literature review indicated that historical materials are rarely used in elementary science classrooms because working with primary sources has been deemed too complex

for young students, and therefore, historical material and context are often introduced through secondary, synthesized materials. Moreover, most teachers have also not been introduced to working with these types of historical sources (Gilliland, Kafai, & Landis, 2000). Yet, our results pointed out that it is possible—with some limitations, as discussed later—to use primary sources in the elementary science classroom.

Our point of departure was, in line with contemporary views of young children's scientific inquiry skills, that given accessible, authentic, and scaffolded activities it would be possible to include primary source materials in elementary science education. We see our classroom work in line with recent reform efforts that propose project-based activities for science learning (e.g., Brown & Campione, 1994; Linn, diSessa, Pea, & Songer, 1994; Roth, 1995). We chose as such a context the work of an archivist, noting in which aspects archival practices overlap with scientific practices. In this project, the researchers, teacher, and the archivist responsible for the Dickey Collection worked together on selecting materials and creating classroom activities engaging students in archival and naturalist practices. Similar to other project-based activities, we chose a familiar and popular activity, such as a field trip, as the equivalent of a naturalist's expedition to collect information about the environment. Many teachers use these field trips to connect them to ongoing classroom activities. Here, we extended the field trip by adding a historical dimension and documenting their day out of school, not in the form of a typical report, but by creating an archive and comparing contemporary with historical sources.

We supported these activities with a visit to the archival repository to see the original Dickey Collection and with structured activities comparing historical and contemporary materials and practices. The combination of all of these efforts created a rich context and proved that historical primary source materials can become part of elementary science classrooms. We selected an archive with visual and textual materials that had local relevance to students. We also created activities with prompts and questions that structured students' evaluation and comparison of their own and historical archives. We provided work materials, such as the description sheets, but with additional explanations that helped students emulate the practices of archivists. We see these parallels between classroom and professional practices—from the archivists' and naturalists' side—as key aspects of introducing historical sources into science inquiry. This pilot study provided us with pointers in what was useful and helpful to get students started.

Benefits of Using Historical Primary Sources

Several outcomes of this case study indicate elementary students' ability to work successfully with historical primary sources: the provision of accurate descriptions in archive creation and the use of time and environment sensitive criteria in archive analysis. We found that in terms of assigning descriptions and annotations to their photographs, students appeared to have few difficulties in supplying simple indicators (e.g., the unique identification number, the title, and the subject of the photograph were all assigned with $>90\%$ accuracy and correctness). Some of the success rate in supplying these description elements can be attributed to the provision of subject categories from which students could choose an explanation of what each descriptive element meant.

Students also used time-sensitive criteria when they referred to artifacts, habitats, and landscape features in evaluating photographs. Many students explicitly stated that they enjoyed working with old science materials because it gave them an opportunity to see how science materials and data collection could be different in different time periods. Students raised issues that related to more complex aspects of time sensitivity and these

provided additional opportunities to discuss changes in scientific practices and issues over time. For example, as mentioned earlier, when students were asked to come up with questions that they would like to ask Dickey if he were alive today, several indicated that they would like to ask him why he killed his specimens, especially since some of them are endangered species. Similarly, when students were asked why Dickey took a photograph that included an eagle and its nest, several students responded that it was because the bird was endangered. In both of these cases, students based their responses on their knowledge that some of these species are today classified as endangered.

There were other important outcomes less clearly articulated in the activities. Students were able to gain an understanding of the sheer volume of the materials created during the scientific process through the trip to the archival repository to view the actual collection and through working with Dickey's field notes. Furthermore, there were aspects in the data documentation that would lead students, in emulating the work of a scientist, to see the need to do very detailed work. These two factors, in particular, would help students view scientific work in a more realistic manner. The historical components also illustrated to students how they are living today in a very different California due to the process of environmental change.

Issues in Using Archival Practices in Elementary Science Classrooms

As we anticipated, there were also some aspects of working with archival sources that students found to be difficult. For example, the students performed poorly in distinguishing between and completing related, but distinct description elements (e.g., title/subject/description). The descriptions which students appeared to find most problematic were those where they were asked to indicate the relationship between the image in hand and other images generated by the same activity (i.e., indicating that they were aware of the collectivity of the documentation); as well as giving a brief rationale for why they had selected a particular image for inclusion. A possible explanation in these cases is that students were being asked to supply the relevant information themselves, rather than identify the correct information derived from options provided. It might also indicate students' lack of familiarity with working with primary sources.

Students also were not always consistent in employing environment-sensitive criteria when evaluating primary sources. For example, when students had selected their photographs from the Ballona Wetlands field trip for inclusion, there were several cases where the students decided to exclude some photographs because they contained houses or other buildings, indicating that the students had not necessarily recognized that such urbanization was evidence of the process of environmental change. The students felt that since they were studying naturalism and since Dickey's photographs had not shown any man-made construction that the buildings were not part of their study nor appropriate for scientific documentation. This result is rather surprising because the majority of students used the presence of historical artifacts in their efforts to date photographs. Also, when students were asked to compare their own archive with that of the Dickey Collection, landscape changes were listed as primary differences.

Another issue concerned the primary source materials themselves. In one instance, we asked students to read Dickey's field notes by looking at photocopies of the original handwritten field notes. Most students found this challenge interesting and motivating. We then provided a transcript of the field notes for further analysis. Here it became clear that students had encountered difficulties not only with deciphering words, but also with the use of technical terms, such as "flushing birds," which needed to be discussed and ex-

plained with the whole class. Although these aspects produced interesting teaching points, the fourth and fifth grade students clearly found the visual materials to be more intellectually accessible.

IMPLICATIONS

Further research is needed on which archival materials can and should be made accessible for educational audiences for science classrooms and how best to do it. Many students and teachers do not have the opportunities to visit original archives as the class had in this study. As noted, there are many primary sources that, due to location and accessibility, are not currently available to teachers and students. Even when historical source materials are available in the original, they may not be in a format whereby they can be accessed off-site (e.g., an historical reproduction or a digitized version). Indeed, over 90% of scientific legacy data is stored in nondigital format. Furthermore, these primary source materials may not be presented in ways that are intellectually accessible for K–12 audiences (Gilliland-Swetland, 1998). In the past, archival materials were rarely appraised, described, and made available for use with the needs of audiences other than historical scholars and institutional administrators in mind, although this is rapidly changing with the development of large-scale digital archives projects, such as the Library of Congress' American Memory (see Tally, 1996).

The four criteria used by the researchers in consultation with the teacher and archivist in order to select historical material to use in the classroom—documentation of naturalist practices, availability of adjunct materials, local relevance, and the visual content—proved to be critical to the classroom project. Another important aspect was that a considerable part of the Dickey collection was already described and contextualized through biographical detail and an extensive finding aid; thus, the researchers' work was limited to finding the pertinent materials within the collection that students could work with. While this might be a difficult and time-demanding task to undertake for any teacher alone, once materials, even in as small a selection as was included in this case study, were made available, they provided fruitful opportunities for engaging students and their teacher in integrative socio-historical investigations.

The opportunity to bring a different, yet important, view on the creation and use of scientific documentation, and the potential to integrate historical context with naturalist activities were promising aspects about introducing the archival component into the elementary science classroom. In our case, we were also able to create a link to the present time by thinking of documentary practices not only in historical terms, but also as an activity that scientists can engage in at the present moment.

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REFERENCES

American Association for the Advancement of Science. (1989). Benchmarks for Science Literacy. New York: Oxford University Press.

Bell, P., & Linn, M. C. (in press). Scientific arguments as learning artifacts: Designing for learning from the web with KIE. International Journal of Science Education.

Brown, A., & Campione, J. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), Classroom lessons: Integrating cognitive theory and classroom practice (pp. 229–272). Cambridge, MA: MIT Press.

Brush, S. G. (1974). Should the history of science be rated X? Science, 183, 1164–1172.

Bybee, R. W., Powell, J. C., Ellis, J. D., Giese, J. R., Parisi, L., & Singleton, L. (1991). Integrating the history and nature of science and technology in science and social studies curriculum. Science Education, 75(1), 143–155.

California Department of Education. (1990). Science frameworks for California public schools: Kindergarten through grade 12. Sacramento, CA: Author.

Carey, S. (1985). Conceptual change in childhood. Cambridge, MA: MIT Press.

Dempsey, L., & Weibel, S. (1996, July/August). The Warwick Metadata Workshop: A framework for the deployment of resource description. D-Lib Magazine. Available: http://www.dlib.org/dlib/july96/07weibel.html.

Driver, R., Guesne, E., & Tiberghien, A. (Eds.). (1985). Children's ideas of science. Milton Keynes: Open University Press.

Duschl, R. A. (1985). Science education and philosophy of science: Twenty-five years of mutually exclusive development. School Science and Mathematics, 85, 541–555.

Gilliland-Swetland, A. J. (1998). An exploration of K–12 user needs for digital primary source materials. American Archivist, 61, 136–157.

Gilliland-Swetland, A., Kafai, Y. B., & Landis, W. (2000). The integration of digitized primary sources in elementary school classrooms: A case study of teachers' perspectives. Archivaria, 48, 89–116.

Klopfer, L. E. (1968). The teaching of science and the history of science. Journal of Research in Science Teaching, 6(1), 87–95.

Klopfer, L. E., & Cooley, W. W. (1963). The history of science cases for high schools in the development of student understanding of science and scientists: A report on the HOSC instruction project. Journal of Research in Science Teaching, 1(1), 33–47.

Linn, M. C., diSessa, A., Pea, R. D., & Songer, N. B. (1994). Can research on science learning and instruction inform standards for science education? Journal of Science Education and Technology, 3(1), 7–15.

Matthews, M. R. (1989). A role for history and philosophy in science teaching. Interchange, 20(2), 3–15.

Matthews, M. R. (1994). Science teaching: The role of history and philosophy of science. London: Routledge.

Metz, K. (1995). Reassessment of developmental constraints on children's science instruction. Review of Educational Research, 65(2), 93–127.

National Research Council. (1995). National Science Education Standards. Washington, DC: National Academy Press.

Roth, W. M. (1996). Authentic school science. Dordrecht: Kluwer Academic Press.

Russell, T. L. (1981). What history of science, how much, and why? Science Education, 65(1), 51–64.

Rutherford, F. J., & Ahlgren, A. (1989). Science for all Americans. New York: Oxford University Press.

Scardamalia, M., & Bereiter, C. (1992). Text-based and knowledge-based questioning by children. Cognition and Instruction, 9(3), 177–199.

Siegel, H. (1979). On the distortion of the history of science in science education. Science Education, 63(1), 111–118.

Solomon, J. (1991). Teaching about the nature of science in the British national curriculum. Science Education, 75(1), 95–103.

Tally, B. (1996, September). History goes digital. D-Lib Magazine. Available: http://www.dlib.org/dlib/september96/09contents.html.

Wandersee, J. H. (1985). Can the history of science help science educators anticipate students' misconceptions? Journal of Research in Science Teaching, 23, 581–597.

Wandersee, J. H. (1992). The historicality of cognition: Implications for science education research. Journal of Research in Science Teaching, 29, 423–434.