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Investigation of Guided School Tours, Student Learning, and Science Reform Recommendations at a Museum of Natural History

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Abstract: A study of docent-led guided school tours at a museum of natural history was investigated. Researchers engaged in naturalistic inquiry to describe how natural history content was conveyed to students and what students gained from this model of touring. They also investigated how the content and pedagogy within the guided tour complemented recommendations from formal science standards documents and informal learning literature. About 30 visiting school groups in Grades 2–8 were observed. Teachers ($n = 30$) and select students ($n = 85$) were interviewed. Researchers found that tours were organized in a didactic way that conflicted with science education reform documents and research related to learning within informal contexts. Students' responses to interview questions indicated high satisfaction with the tours but low levels of science learning. © 2003 Wiley Periodicals, Inc. J Res Sci Teach 40: 200–218, 2003

Museums are important and well-respected educational and cultural resources. In particular, they serve as learning environments for students who take part in guided museum tours. In this article, we present the results of an investigation of guided tours of school groups at a large natural history museum. We describe and discuss the nature of these tours and how their structure and content relate to recommendations for science education reform [American Association for the Advancement of Science (AAAS), 1993, 1994; the National Science Education Standards (National Research Council [NRC], 1996)], and to findings reported in informal learning literature (e.g., Falk & Dierking, 2000; Hein, 1998). Finally, we discuss whether formal science reform recommendations could or should be used to enhance learning in informal settings.

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Conceptual Framework

Museums are popular with families and school groups and they serve as ideal environments to supplement learning (Falk & Dierking, 1992, 2000; Griffin & Symington, 1997, 1998; Ramey-Gassert, Walberg, & Walberg, 1994; Rennie & McClafferty, 1996). Gardner (1991) argued that whereas schools have become increasingly anachronistic, museums have retained "the potential to engage students, to teach them, to stimulate their understanding, and most important, to help them assume responsibility for their own future learning" (p. 202). Falk and Dierking (1997) found that school trips to museums and other informal environments promote long-term recall of science content. Their study revealed that 80% of children and adults could recall three or more specific events linked to a school trip; many of these responses related to exhibit content. This study is conceptually framed by knowledge related to learning in museums, including the relevance of personal, social, and physical contexts (Falk & Dierking, 2000), as well as a social constructivist view (Driver, Asoko, Leach, Mortimer, & Scott, 1994). It is also framed by national science reform efforts (AAAS, 1993; NRC, 1996) that recommend that students should attain high levels of scientific literacy through active participation in their learning and discourse with others.

Despite recent attention to the educational potential of museums, the nature of learning in museums is often difficult to define, and consequently learning is difficult to measure (Hein, 1998). Cognitive scientists view learning as an interpretive process with new information processed only within the context of an individual's prior knowledge and experiences. For students to construct understanding, they must be provided with opportunities to verbalize their ideas, test these ideas through dialogue with each other, and make connections between the phenomena examined in relation to personal experiences (Julyan & Duckworth, 1996). Social constructivists (e.g., Driver et al., 1994) view learning as a process that occurs through discourse with others and within specific contexts. When students learn science, they must adopt a way of thinking that includes being "socialized to a greater or lesser extent into the practices of the scientific community with its particular purposes, ways of seeing, and ways of supporting its knowledge claims" (p. 8). Blud (1990) found that social interaction at museums could enhance cognitive processes.

The importance of the sociocultural context in an informal setting is emphasized in Falk and Dierking's Contextual Model of Learning (2000). This conceptualization suggests that the sociocultural context as well as the context of personal experience and the physical environment all interact to contribute to the learner's experience. Within this model, a learner's past experience with an object on display, her familiarity with the location, and her discussion with a companion must all be considered when examining learning. Csikszentmihalyi and Hermanson (1995) identified the importance of personal relevance and intrinsic motivation as they asserted that learning involves more than just the intellect of an individual; it includes his or her emotions or feelings.

Falk and Dierking (2000) identified eight key factors that affect learning (Table 1) within three contextual domains: personal, sociocultural, and physical. They contended that if any of the eight principles are neglected, meaning making in the museum is more difficult. Several other researchers have also made recommendations regarding the use of informal science institutions. Griffin and Symington (1998) identified specific characteristics for museum visitors that would result in prime conditions for learning: (a) taking responsibility for learning, (b) active involvement in learning, (c) purposeful manipulating of objects, (d) making links between exhibits and ideas, (e) sharing learning with peers and experts, (f) showing confidence in learning by asking questions and explaining to peers, and (g) responding to new information or evidence. Griffin and Symington also specified that these indicators have the potential for measuring specific learning outcomes.

Table 1
Key factors that influence learning within three contexts (Falk & Dierking, 2000, p. 137)

Personal context
Motivation and expectations
Prior knowledge, interest, and beliefs
Choice and control
Sociocultural context
Within-group sociocultural mediation
Mediation facilitated by others
Physical context
Advance organizers and orientation
Exhibit design
Reinforcing events and experiences outside the museum

In a more general sense, science learning can also be examined with respect to standards and recent educational reform movements. National reform documents for teaching science advocate the use of themes, unifying concepts, and an emphasis of depth over breadth (AAAS, 1993; NRC, 1996; New Standards, 1997). The National Science Education Standards (NRC, 1996) focus on fundamental concepts rather than numerous topics, isolated facts, and difficult vocabulary. This view of science teaching is also supported by the Third International Mathematics and Science Study (TIMSS), which reported that American students get a ''splintered vision'' of science owing to the large number of topics schools cover during an academic year (Schmidt, McKnight, & Raizen, 1997). TIMSS findings indicated that schools often spend time focusing on a large number of subjects, giving students little time to investigate one topic in depth. Could learning in museums be suffering from the same topic overload as the formal school curriculum? We will investigate this question in the context of docent-led school tours.

The National Science Education Standards (NSES) (NRC, 1996) recommend that students develop an understanding of science that enables them to use their knowledge in personal, social, and historical contexts. The NSES defines learning as an active process through inquiry, involving ''making observations, posing questions, examining books and other sources of information to see what is already known, planning investigations, reviewing what is known, proposing answers and explanations, and communicating results'' (p. 9). In addition, students engage in inquiry to develop skills necessary to (a) understand scientific concepts, (b) become independent inquirers about the natural world, (c) understand the nature of science, and (d) appreciate ''how we know'' what we know in science (p. 105).

Standards documents provide a framework of science concepts that students should be familiar with at particular age levels; however, they do not limit this learning to a particular setting. The NSES recognizes that ''the classroom is a limited environment. The school science program must extend beyond the walls of the school to the resources of the community'' (NRC, 1996, p. 45). Furthermore, the standards suggest that museums and science centers ''can contribute greatly to the understanding of science and encourage students to further their interests outside of school'' (p. 45). With this in mind, we chose to use recommendations such as the NSES to provide a lens through which to examine the guided tour experience.

Natural history museums feature a plethora of information, typically in the form of science specimens, cultural and historical artifacts, and related labels or signage. Although there is the potential for considerable learning, questions arise regarding how much of this information should be introduced to students during a 1- or 2-hour tour at the museum and by what means

the information and artifacts should be presented or shared with students to promote optimum science learning and appreciation for museum collections. These issues will be addressed as we examine the context of guided tours, observations of student and docent interactions, and interviews with teachers and students at a museum of natural history.

Context of the Study

A large urban natural history museum was the setting for this study. The museum's mission statement, at the time of the study, described its goal as advancing knowledge and enabling people of all ages, backgrounds, and interest to appreciate their natural and cultural heritage. The museum's collections include over 35 million specimens and artifacts covering 4.5 billion years of Earth's history. School tours operate Monday through Friday from 10:00 a.m. to 1:00 p.m. and are conducted by trained volunteer docents (with a docent to student ratio of approximately 1:30). During a typical week, 2100 students in Grades 2–8 participate in guided tours of a wide variety of exhibits including natural science, history, and culture. Over 70 school districts participate in guided tours from 10 different counties in southern California.

During guided tours, students are introduced to a variety of fossils, animal specimens, and other items related to natural science as well as many one-of-a-kind artifacts that define the history of California and the United States. This study focused on guided tours within the following nine exhibit halls: Marine Biology, Birds, Gems and Minerals, Pre-Columbian Civilizations, Cenozoic Mammals, Dinosaurs, North American Mammals, African Mammals, and California History.

Method

We engaged in naturalistic inquiry (Lincoln & Guba, 1985) to understand (a) how natural history content was conveyed to students, (b) what students gained from their visit, and (c) how the content and pedagogy of the tour complemented recommendations from formal science standards documents and informal learning literature.

We selected 30 visiting school groups for the purpose of covering a range of student grade levels (Grades 2–8), student ethnicity, school district origin, museum exhibitions visited, and their assigned museum docent. School groups who signed up for a tour during May and June 1999 were considered. After an analysis of different grade levels and tours, we chose 5 second-grade groups, 6 third-grade groups, 5 fourth-grade groups, 5 fifth-grade groups, 5 sixth-grade groups, 2 seventh-grade groups, and 2 eighth-grade groups. School groups ranged from 12 to 32 students per tour.

Ten data collectors worked in pairs as nonparticipant observers to investigate 1-hour, docent-mediated school visits in one of the nine halls. The data collectors used two observation instruments and two interview protocols to collect evidence for this study. These instruments were developed by researchers to describe the context of the school tour, self-reported student learning, and teacher perspectives. Data collectors participated in a half-day training session and practiced with each instrument before actual data collection commenced.

Observations

The first observation instrument, Content and Activities (Appendix A), focused on the time and task sequence of the visit, including questions such as "How long did the docent speak?" "What content was presented?" and "How did the handling of objects take place?" Data collectors recorded observations of interactions among the docent, teacher, students and other individuals, and noted what type of interaction took place, such as (a) lecture; (b) questions,

explanations, or comments; (c) manipulation of objects, observing or listening; (d) management of group behavior; and (e) any off-task behavior. During observations data collectors systematically recorded docent, teacher, student, or other individual behavior every 5 minutes or when an activity changed. Field notes were written beside each code to document specific questions or comments made by docents, teachers, or students. Specific on-task or off-task behaviors were also recorded, including the number of students who engaged in those behaviors.

The second data collection instrument, Group Dynamics (Appendix B), focused on parts of the tour that related to students' age, gender, and culture. Data collectors recorded their observations that indicated any docent behavior related to student age, ethnicity, gender, culture, or language. After each observation period, data collectors determined docent sensitivity on a scale of 1 to 4, with 1 representing not sensitive and 4 representing very sensitive. They recorded "Don't know" if no evidence was observed. Exhibit objects and content was noted when relevant.

Each pair of data collectors recorded all observation data independently then debriefed their observations and codes after the tour. If they found disagreement between their observations, each researcher rechecked the data and field notes to determine what was observed and how data codes were designated. All disagreements were eventually resolved in this way.

Teacher, Student, and Staff Interviews

For each school group, a brief two-part teacher interview ($n = 30$) was conducted by one of the two data collectors on-site at the museum. At the beginning of the tour, the questions focused on the teacher's perception of the purpose of the visit, the process for selecting the specific exhibit to be visited, and possible connections of the visit to the ongoing curriculum for the teacher. At the end of the visit, the interview focused on the perceived value of the visit and suggestions for improving it in the future (Appendix C). These questions were developed to gauge the teachers' perception of the content of the tour and its connections to the formal school curriculum.

Two to four students from each school group were selected for a 5- to 10-minute interview ($n = 85$) immediately after the tour. Data collectors made an attempt to interview boys and girls including students of diverse ethnic backgrounds. Students were asked what they liked and did not like about the tour, what they had learned during the hour, and one big idea they gained from the exhibit. They were also asked to state whether they liked touring with a guide (Appendix D). Questions were designed to determine what aspects of the tour that the students valued most and what science content they learned from the tour and exhibit. Although these interviews were brief, the content of the student responses provided insight into the students' perceptions of the content of the exhibit, their self-reported learning, and the tour.

Interviews with four museum staff members were also conducted to gain a better understanding of how the guided tour program was situated within an education department at this natural history museum. These interviews helped to develop a historical context for the tours and to explain docent education and training.

Analysis

After the data collection, all observations and interviews were transcribed verbatim and analyzed using open coding procedures (Strauss & Corbin, 1990). This resulted in specific patterns and categories associated with (a) the structure of the tour and interactions among docents, students, and teachers, (b) self-reported student learning and their perceptions of the tour, and (c) the extent to which the content and pedagogy of tours were compatible with science education reform recommendations and suggestions from the informal education literature. The

authors met to review and discuss the meaning of each category defined from consistent patterns found within the data.

Student and teacher interviews were coded and categorized according to the type of response. Frequencies and percentages were calculated when appropriate. Only data from students who provided a response for a particular question were analyzed.

Although this study is limited to a series of guided tours observed at one museum of natural history in southern California, the findings may be used to provide a foundation for inquiry into additional guided tour models and determine their purpose and relevance in science teaching and learning.

Findings

Consistent patterns that resulted in categories during data analysis will be presented within four different sections. These areas include (a) the context of the guided tour including a typical tour description and exhibit organization and design, (b) students' self-reported learning and their perceptions related to the tour and exhibit content, (c) the guided tour and its relationship to national standards reform documents and learning in informal contexts, and (d) the guided tour within the context of the institution.

Structure of the Tour and Docent, Student, and Teacher Interactions

A typical tour was a structured, narrative, docent-directed experience in which students and teachers moved together as a whole group. The vignette below provides a description of a tour based on observation data collected from a tour of a marine biology hall (AC-MB-5/13).[1]

Vignette: A Guided Tour. Twenty-six fifth-grade students from Eagle Elementary School (a pseudonym) arrive at 9:45 a.m. for their 10:00 a.m. tour of the Marine Biology Hall. At 10:05 a.m., students enter the Hall, where Docent S. introduces herself and asks the students to sit on the floor. She tells students, "I will give you information about the hall but I will also give you time to touch and tour yourself." She begins a short lecture at 10:07 a.m. and tells students that the ocean is the biggest part of Earth. She asks a variety of questions as part of her presentation, such as, "Do fish have babies in an estuary?" and "Do you think that this animal lives in the sand?" Next, she shows students a variety of shells on display belonging to sea creatures such as abalone, sea star, and lobster shell. One student asks, "Are sea stars hard to get?" The docent responds that sea stars are plentiful in some areas of the ocean but their color usually changes when they die. At 10:20 a.m., Docent S. allows students to self-explore the exhibit hall. After 5 minutes (about 10:25 a.m.), Docent S. calls the students back together and asks questions related to what they have seen: "Who saw the mud?" and "Did you see examples of high and low tides?" At this point, some of the children become distracted and Docent S. asks them to "Please pay attention." Students return their attention to Docent S. for a short time, but then begin to examine displays and touch objects nearby while Docent S. continues to inform students about different areas of the ocean and the marine life that lives there.

After the discussion concludes at 10:32 a.m., Docent S. introduces students to a variety of unique objects such as a sea urchin, a sea star, a whale tooth, baleen from a whale, and an abalone shell. Each time Docent S. presents a new object, she provides information about it before asking students to pass it around the circle. Students are talking with each other, asking questions about the object or making comments such as "Is this real?" and "This [whale tooth] looks like a rock." As the students' interests and conversations are drawn to these individual objects, Docent

S. continues talking about new objects, continuing the show and tell for almost 20 minutes. Much of the students' attention during this time remains on the objects rather than the docent presentation.

At 10:52 a.m., Docent S. leads students to a reef exhibit. She asks students to look at the different colors in the reef and the fish around it and begins a brief talk about the different reef organisms and their adaptation. At 10:55 a.m. Docent S. shows students a preserved oarfish. Students immediately ask "Is it real?" Docent S. informs them that it is indeed real and that it is almost 15 ft long. At 10:57 a.m. Docent S. thanks the teacher, parent chaperones, and students for coming to the museum and leads them back to the grand steps.

Structure and Content of the Tours. More than 75% of the tours observed were docent-focused, lecture-oriented, and often patterned with docent providing content information, docent asking a question, and then group moving to another area within the hall. However, about 35% of the docents were observed beginning tours with open-ended thought-provoking questions, yet these questions were not revisited during the tour. Students were not observed making decisions or working collaboratively. Small groups developed informally when a teacher, docent, or parent voluntarily engaged in short discussions of the exhibits or during self-exploration time. Observations suggested that limited modifications were provided to assist the needs of younger students or second language learners.

Analysis of observation data revealed the following:

1. Tours focused on facts or stories rather than big ideas or concepts. In 25 of the 30 tours (83%), docents guided the students throughout the exhibit highlighting different facts related to the objects or specimens. The guided tour vignette of the marine biology hall illustrates how one docent talked about various facts related to marine life without focusing on overarching concepts. This was a typical scenario based on observations of all tours.

2. The scientific and historical vocabularies used during the tours were often too advanced for students. In 19 of the 30 tours (63%), docents used vocabulary above the students' grade level. Field notes from two different African Mammal Hall tours provide examples of the use of advanced vocabulary. "Docent uses words such as *nourished*, *reconstructed*, *preserve*, *class*, and *family* with second graders" (DM-Afr Mam-5/5). "Docent used unfamiliar language frequently. New words were defined and then immediately used in the conversation. There was a lot of content communicated with new vocabulary" (HH-Afr Mam-5/6).

3. Sensitivity to individual and cultural differences was rarely observed. About 90% of the observation data indicated that docents followed a particular outline or script. "The docent seemed to have a set script. He moved students along without assessing their understanding of exhibit content or attempting to meet their needs" (EM-Dino-5/21). "The docent's agenda did not change to meet the students' Spanish language needs or personal inquiries about some of the exhibits" (AC-MB-5/13). However, it should be noted that three of the docents addressed students' needs: "The docent made connections to the students' language. Half of the class was Hispanic. The docent translated different objects from their English name to the Spanish name such as *mono*, *pinions*, *ensino*, *brea*" (EM-ECA-5/21).

4. Closed and/or factual questions that did not require complex responses from students were observed. Questions were asked without follow-up, elaboration, or probing.

A total of 18 docents (60%) asked factual questions throughout the tour, 8 docents (27%) asked a combination of open-ended and factual questions, and 4 docents (13%) asked mostly open-ended questions. Field notes from a second-grade tour of the African Mammal Hall indicate that:

> Students played a more passive role in this tour, looking and listening most of the time. Docent asked questions that pertained to new information just presented such as "What is a mammal?" and "What is the difference between real and alive." (HH-Afr Mam–5/6)

During a tour of the Gems and Minerals Hall similar observations were noted:

> The group entered the hall and sat down. The docent asked questions such as "What is a mineral?" One student raised his hand and said, "A mineral grows by itself under the earth." The docent was satisfied with that comment and then asked, "What's the earth made of?" None of the students volunteered an answer so the docent answered for them, "Elements." The docent continued the discussion and asked questions that required students to define terms such as *crystal*, *gem*, and *sedimentary*, *igneous*, and *metamorphic rocks*. (LM-G&M-5/13)

5. The structure and content of the tour provided minimal connections between the content of exhibit halls and the lives and prior knowledge of the students. Docents seldom provided analogies, information, or examples related to students' life outside the museum. Field notes of a second-grade class visiting the Cenozoic Hall exemplify this.

> Students sit on the floor as the docent tells students about the different halls at the museum. The docent says that this [Cenozoic Hall] is a prehistory mammal hall. He continued to provide information for about 5 minutes without asking students for additional information or personal reactions. (AC-Cenz-5/7)

Another example was noted in the Pre-Columbian Hall, demonstrating that this approach was not limited to science halls:

> The docent asked the students, "Everyone knows where Peru is, right?" Although students did not answer, the docent asked another question: "What are these mountains?" Again students did not answer, but the docent asked, "How does Andes sound?" The docent continued to ask rhetorical or factual questions as she showed students artifacts from the life of ancient people in Peru. The docent did not ask for student questions, did not respond to student questions, and did not make any connections between life in ancient Peru and their life now. (DM-PC-5/14)

Interview data showed that teachers made suggestions for improving the guided tours. They stated that adding more hands-on activities, increasing student interaction, and providing more time for students to explore exhibit halls freely would improve their visit. One teacher explained, "I'd like to see the content of the tour connect more with the student's perspective—it's like finding out how you're going to hook them . . . like when the docent was talking about the ball game, that would have been a perfect place to really talk to students about comparing it to their lives" (T25.5/7). About 20% of the teachers indicated that they would also like tours to provide more time for student questions and student inquiry. Despite these recommendations for improvement, 67% of the teachers expressed satisfaction with the museum tour.

Student Learning and Perceptions

During the interviews, students made little reference to what they were learning in school or how the content of the tour connected to other areas of their life. They stated what they liked: "I liked the monkeys (Second-grade student, African Mammal Hall)" and "I liked when [the docent] passed around the skin (Third-grade student, Dinosaur Hall)." They also provided factual information: "Native Americans made a stick out of the tree (Fourth-grade student, California History Hall)" and "Some dinosaurs are big and some are small (Third-grade student, Dinosaur Hall)." These comments conveyed information that, although accurate, did not usually connect to any overarching concepts of the exhibit hall.

Students were also asked to describe at least two things that they learned from the exhibit and tour and to give one big idea related to the exhibit. Data from these two questions (151 responses from 85 students) were integrated and coded according to the type of response, as shown in Table 2. Levels of learning were determined to gauge the students' understanding of the concepts associated with the exhibit. Student responses to these interview questions were coded as representing high, medium, or low levels of learning based on the complexity of their articulation of facts, concepts, and inclusion of multiple concepts. Students' responses were coded as representing a low level of learning if they stated trivial facts without the inclusion of concepts and/or when they reported inaccurate information. Students' responses were coded as representing a medium level of learning if they included concepts (multiple facts related to each other) with little elaboration of exhibit content. Students' responses were coded as a high level of learning if they included multiple concepts and elaborated with accurate elaboration or explanation.

Overall, 91% of students' responses represented medium to low levels of learning, whereas only 9% of the students demonstrated high levels of learning. Students were generally able to articulate what they had learned from the exhibit tour, yet few students were able to report more than unrelated facts or descriptions. About 61% of the students, whose responses were coded as low level of learning, made remarks such as "Elephants have horns" (Second-grade student, African Mammal Hall), "It's something part of the earth, like the rocks . . . I forgot" (Fifth-grade student, Gems and Minerals Hall), and "The rabbit skin smelled and felt spiky" (Third-grade student, California History Hall).

Students' responses that were coded as representing a medium level of learning provided more details and accurate information when discussing what they had learned: "Dimetrodons are

Table 2
Student response codes and frequency (n = 151)

Type of Response	Frequency	%
High level of learning		
Multiple concepts with accurate elaboration	14	9
Medium level of learning		
Concept with little or no elaboration	46	30
Low level of learning		
Recollection of object or animal	22	15
Description of animal or object	23	15
Description of animal behavior or object use	34	23
Affective response	3	2
Do not know/cannot remember	9	6
Total	151	100

Note. Percentages are rounded to the nearest whole number.

reptiles, not dinosaurs. Water reptiles aren't dinosaurs [either] because they don't live on land'' (Sixth-grade student, Dinosaur Hall), and ''There are many different kinds of fish and other things, like sand dollars, that live in the ocean'' (Third-grade student, Marine Biology Hall).

Students' responses were coded as representing a high level of learning if the responses integrated concepts and provided appropriate details when students explained what they learned from the exhibit: ''The bigger they are [birds], the more food they need to eat. If they have more [larger] bones, they fly less fast; if they have less bones, they fly faster'' (Eighth-grade student, Bird Hall).

Student misconceptions were noted during data analysis. The most common misconception related to the Cenozoic Hall. Although there were no dinosaurs present within this hall (only skeletons of extinct mammals), students stated that they learned about dinosaurs. Other students expressed misconceptions or generalizations such as ''Mammals have horns only to protect themselves'' (Third-grade student, North American Mammal Hall) and ''Fish light in the night and glow'' (Fifth-grade student, Marine Biology Hall). Although some of this information is accurate for specific species, students often made generalizations based on information presented during the tour.

When students ($n = 85$) were asked if they liked touring the exhibit with a museum guide, over 92% of the students responded ''yes.'' Only 3 % said ''no'' and 5 % said that they were ''not sure.'' They liked that docents knew a lot about the halls and explained different aspects of the exhibit. Typical student comments included, ''She showed you things people used long ago (fourth grade student, California History Hall),'' and ''He explains things and makes it easier to understand (second grade student, Dinosaur Hall).'' Other typical comments related to exhibit content included: ''He taught us about how people got gold and how their work was so hard (fifth grade student, Gems and Mineral Hall),'' and ''She showed us many animals and mammals (third grade student, North American Mammal Hall).''

Students ($n = 76$) were also asked to state what they liked most about the tour. Generally, they were enthusiastic, excited about the artifacts and specimens included in the exhibit, and stated that they had learned a lot of ''new things.'' Over 51% of the students provided responses that related to the exhibit (e.g., ''head of a girl,'' ''dioramas with animals'') and 21% provided responses that were related to the hands-on objects from the docent (e.g., ''touching things, I like to feel things''). Other students said that they liked a particular topic (e.g., dinosaurs), learning (e.g., ''it teaches us well), and movement (e.g., ''walking around''). Other categories with total responses and frequencies are presented in Table 3.

Table 3
Student responses related to what they liked about the guided tour ($n = 76$)

Categories	Frequency	%
Docent related	1	1
Topic related	3	4
Exhibit related	39	51
Cart/touching related	16	21
Learning related	2	3
General exhibit reference	5	7
Generally pleased	7	9
Movement related	3	4
Total	76	100

Note. Percentages are rounded to the nearest whole number.

Guided Tour, National Reform Efforts, and Learning in Museum Settings

The guided tours observed in this study demonstrated limited connections to key science education standards or informal learning priorities. Tours were fast-paced, covering displays and providing information. Much of the information presented during the tour was fact based and did not focus on overarching ideas or concepts within the exhibit. Observations and interviews with students and teachers revealed that tour content seldom connected to what students were learning in school or their prior knowledge or interests. These findings do not conform to AAAS's (1994) recommendations that students understand key concepts and principles and emphasize thinking skills rather than memorization of terms. Nor do they acknowledge Falk and Dierking's Contextual Model (2000) or and Griffin and Symington's (1997) recommendations for school trips that emphasize the importance of the learner's prior knowledge, the need for choice, or the importance of social interaction.

Overall, we found the natural history content was presented in a didactic or narrative style with limited dialogue among docents, students, chaperones, and teachers. This approach runs counter to recommendations by the NSES (NRC, 1996) that educators take roles as facilitators of learning rather than transmitters of knowledge. The NSES states that educators should (a) focus and support inquiries while interacting with students, (b) encourage discourse among students about scientific ideas, (c) challenge students to take responsibility for their own learning, (d) respond to student diversity and encourage participation of all students, and (e) model skills of scientific inquiry. Although these standards were written for teachers and students in a formal science classroom, it seems that many of these standards could be applied to informal science learning experiences such as docent-led tours where there is opportunity to affect student thinking.

Inquiry-based experiences recommended by the NSES were not a major focus of the tours that we observed. However, a museum or other informal venue could be a pertinent place to promote activities that allow students to ''become independent inquirers about the natural world'' and investigate personal questions related to scientific concepts (NRC, 1996, p. 105). A museum, particularly a natural history museum, offers a variety of specimens and objects that have the potential to complement many of the standards. The mere content presented within this natural history museum (because it includes science, history, and culture) has the potential to enhance students' understanding of science in personal and social perspectives, another aspect that is also included as an NSES standard.

About 47% of the teachers indicated that the tours should be less structured and more student centered. They also felt it was the museum's role to coordinate more inquiry-based formats, free choice, and hands-on objects. Their recommendations correspond with those set forth by the NSES (NRC, 1996) and the informal science education literature (Falk & Dierking, 2000; Griffin & Symington, 1998; Katz & McGinnis, 1999). Interestingly, the education staff at the museum where this study took place also shared these teachers' suggestions. Educators at this museum wanted students to encounter meaningful educational experiences during guided tours that would help them feel comfortable in a museum setting and make personal connections to the exhibits (S4.4.28). Nevertheless, few of these experiences were observed throughout the 30 different guided tours that we investigated.

Exhibit organization itself was a notable obstacle to promoting students' understanding of the unifying ideas that tie the scientific facts together. Exhibits were organized and labeled in ways that emphasized the Museum's cataloguing orientation. Examples include the hall names (e.g., North American Mammals Hall) and the way dinosaurs were labeled in highly scientific nomenclature. Students did not encounter displays that blended categories of exhibits to show

connections between the categories of artifacts or simpler, more accessible labeling of artifacts to aid retention and understanding of the information presented.

Guided Tours and the Larger Context

An educational program is undoubtedly influenced by the context in which it functions. In the case of the school-touring program discussed here, the setting helps provide some rationale for the kinds of teaching and learning observed. Observation data suggested that the physical settings of the exhibits seemed to reflect a priority of security, preservation, and conservation over educational interests—a traditional natural history museum archetype. One of the most powerful attractions of the museum is the fact that that the artifacts are real. Because of their scientific significance or historical value, some items were protected behind glass or gates and only a small number of objects were directly accessible for touching or moving.

The school tour and docent program at the museum have been in operation in their present forms for over 20 years. The tours we observed typify museum tours in many natural history and other museums in that they involve an expert guiding a group through the museum using a lecture format. In addition, these programs are popular, with most available touring slots for the entire school year filled by mid-January (S3.4/28).

The nature and features of the tours we observed during this study must be viewed in the context of the training sessions that the museum docents attend. Training practices at the time of this study were deeply rooted in providing docents with as much content as possible about each of the halls within the museum. Many of their training sessions involved presentations by museum scientists and were highly complex in nature. Although docents were provided with some training on how to interpret objects, as well as pedagogical concepts and touring techniques, the content information still occupied the majority of their yearlong training (S2.4/21). It is likely that a training of this format sends a hidden message that content is the most important component because it occupies the greatest percentage of time.

Discussion

The findings indicate that guided tours at the natural history museum in this study provided an experience that was satisfactory to students and teachers but mostly inconsistent with recommendations from science education reform documents and informal science literature. Given this information, how could or should a guided museum tour be structured based on current science education reform efforts? What might be done to enhance a focus on key learning concepts during the tour? How can we enhance student learning while retaining the informal nature of a museum? Clearly, the answers do not involve reorganizing the museum along the lines of every science education standard and science reform initiative, as school students are but one part of the museum audience. However, much could be done to improve the connection among the natural science content and artifacts available at the museum and the core concepts and learning recommended by science reform documents. Meaningful change would involve examining the current content and pedagogy and determining how national science reform efforts could be used to guide meaningful learning while retaining the museum's informal physical structure.

Tours observed during this study were lecture based and provided limited interaction among docents, students, and exhibit artifacts. This differs from the informal science literature that acknowledges learning depends on interactions among the personal, sociocultural, and physical contexts (Falk & Dierking, 2000) during the museum experience. The tour format observed in this study also differed from recommendations by the NRC (1996) that educators take roles as

facilitators of knowledge and to encourage personal inquiry and learning through social and personal processes. Based on our findings, we have devised an alternative docent-led tour format that addresses features of learning in informal science contexts (Falk & Dierking, 2000; Griffin & Symington, 1998) in addition to science education reform efforts related to content and pedagogy (California Academic Standards Commission, 1999; NRC, 1996; Schmidt et al., 1997). Table 4 presents the specific formal science content used as a foundation of this vignette. The three contexts for learning (personal, sociocultural, and physical) as described in Falk and Dierking's Contextual Model of Learning (2000) are also included: (a) advanced organizers are provided with an orientation that highlights open-ended questions related to student experiences outside the museum (physical context), (b) students work in interactive groups with adults who act as facilitators (sociocultural context), and (c) students are given the opportunity for choice and expansion of their prior knowledge (personal context). The changes that we outline in the following vignette would not involve revising the physical structure of an exhibit, but instead would place more emphasis on overarching concepts and active student involvement.

Vignette: The Alternative Tour

The tour experience would begin as the docent meets a group of third-grade students and guides them to the North American Mammal Hall. After a brief introduction, students would be invited to explore the hall while considering a guiding question such as "How are these animals alike?" or "How do these animals protect themselves?" These questions refer to big ideas and require students to recall personal experiences and observations.

After this 5- to 7-minute orientation period, students would regroup with the docent in front of one of the dioramas. Students would be encouraged to talk about what they saw (similarities, differences, and protection), leading to a brief discussion of animal differences and the importance of adaptations. Only a few words such as *habitat* and *adaptation* (California Academic Standards Commission, 1999) would be introduced or clarified.

After this brief discussion, students would be introduced to their primary task for the visit: an in-depth examination of one of the animal dioramas. The teacher would divide the class into five predetermined groups of 4–6 students, each group led by an adult (teacher, aide, or parent chaperone). The directions for grouping the students and guidelines for adult helpers would be provided to the classroom teacher before their arrival at the museum. Each adult would be

Table 4
Formal science education standards related to the revised tour vignette

National Science Education Standards (NRC, 1996)
Life sciences (Grades K–4)
"Each plant or animal has different structures that serve different functions in growth, survival, and reproduction."
"All animals depend on plants for food. Other animals eat animals that eat the plants."
"An organism's patterns of behavior are related to the nature of that organism's environment. . . . When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations."
State of California Science Content Standards (California Academic Standards Commission, 1999)
Life Sciences, Grade 3:
"Adaptations in physical structure or behavior may improve an organism's chance for survival."
Life Sciences, Grade 4:
"Living organisms depend on one another and on their environment for survival."

given a color-coded learning tote bag that contained data cards, marking pens, and several touchable specimens related to one of the species in the hall. These touchable items might include an animal fur, a skull or jaw replica, a horn or antler, or other items or replicas related to the animal.

Once at the diorama, the adult helper would remove the touchable artifacts from the tote bag and circulate them among the group. Several prompting questions would be provided for the helper (on another color-coded card) to help students think more critically about the items they touched. After sharing ideas about the items, the helper would distribute the data cards, one for each pair of students. Students would be encouraged to respond to the questions on the card, with minimal guidance from the adult helper. The open-ended questions developed for the data cards would invite a variety of responses and give students the option of writing or drawing their responses. These questions would also be linked to the formal science content standards (California Academic Standards Commission, 1999). In particular, the data card questions would ask students to think about the animal's body structure and how different features might help it survive in its habitat. Food and protection would be two particular areas of focus. Each group would be asked the same series of questions but each group of students would examine these within the context of a different animal.

Students would be given approximately 20–25 minutes to complete this brief investigation, after which they would regroup with the docent to discuss their findings. Students would share their results through verbal and even kinesthetic responses. Sample questions might include, "Whoever studied an animal that is a meat eater, stand up," or "Stand on this side if your animal is able to survive cold weather [kinesthetic]. Now, describe your animal [verbal]." Using these questions, the docent would help students see the diversity of adaptations that allow these animals to survive in a variety of habitats and explore features common to carnivores and herbivores.

After this 5- to 10-minute discussion, students would be given one additional challenge. Student pairs would be directed to reexamine the animals in the hall once more and choose another display to observe. Once the display was chosen, students would be asked to complete a survival challenge. Each challenge card would depict and describe a particular habitat such as a desert, mountain, or tundra; students would then determine whether the new animal they chose could survive there. Students would then provide some rationale for their choice based on the kinds of adaptations they saw for that animal. After the challenge, students would regroup one final time to discuss their findings. The docent would again use similar techniques to guide sharing. At the end of the tour, students would be invited to roam the hall freely and examine some of the items from the other learning tote bags.

Connections between Science Learning and the Guided Museum Tour

The vignette above describes a learning experience unlike those described in the findings section of this study. Students would have time for talk and exploration, thereby giving them time for personal reflection and connections and acknowledging the personal context of the visit. Small group activities would provide for social interactions among teachers, students, docents, and chaperones, thereby enhancing the sociocultural context of the visit. This tour also provides time for students to become acquainted with and explore the physical aspects of the exhibits in greater depth. All of these components are compatible with recommendations by Schmidt et al. (1997), the NRC (1996), and the AAAS (1993). Students are given time to make personal connections as they examine exhibit content and discuss their findings. The focusing questions and activities help bridge connections between the formal science curriculum and the unique artifacts and exhibits of the museum. In addition, the content of the tour would be aligned with developmentally

appropriate content outlined in the National Science Education Standards, Grades K–4 (NRC, 1996) and the Science Content Standards for California Public Schools (State of California Academic Standards Commission, 1999).

This tour format provides a variety of activities within one exhibit area where the museum docent takes on a role as facilitator of learning rather than lecturer. Moreover, these activities are supported by Griffin and Symington's (1998) recommendations related to favorable conditions for learning in museums. The proposed changes to the tour experience would encourage more active involvement in learning, purposeful manipulating of objects, meaningful links between exhibits and ideas, and sharing learning with peers and experts.

Ramey-Gassert (1997) acknowledged that when reevaluating policy within museums on how connections with schools are made, it is helpful to be aware of reform documents such as formal content standards. She asserted that collaborative efforts between schools and informal institutions should be more creative and accepting of change. Building on this notion, Katz and McGinnis (1999) suggested that informal science educators proceed cautiously when matching informal science programs to formal science education goals given the fact that their identities are complementary but different. They reported an informal elementary science education program that maintained its informal identity while sharing four distinct goals with formal science standards. These shared goals include the increase of (a) science knowledge, (b) science activity and career access to parts of the population that have been traditionally underrepresented, (c) the whole population's concern with science literacy, and (d) understanding that comes from research in teaching and learning science (p. 10). Given the information obtained from this study, we support recommendations by Katz and McGinnis (1999) but propose extending these recommendations to include specific pedagogical standards that can be shared between formal and informal science institutions, especially when guided tours are commonplace. Pedagogical standards that translate into a guided tour environment include (a) meeting the interests and experiences of students, (b) focusing and supporting student inquiries, (c) challenging students to accept responsibility for their own learning, and (d) encouraging discourse among students about scientific ideas (NRC, 1996).

Recommendations

Although a detailed examination of the structure and content of the school tours in this study revealed some positive elements, we have outlined suggestions for how museums could enhance guided tours to be more effective in promoting science learning and appreciation. These suggestions include more active student participation, specific learning cues, and expanded personal, social, and physical components based on Falk and Dierking's (2000) work. The findings from this study indicate that personal and social contexts were not specifically addressed when delivering the content and structure of guided tours. In addition, the physical context of the tour seldom connected the exhibit content to students' life outside the museum. The following are examples of pedagogical elements that could be incorporated into guided docent tours:

1. Incorporate orientation and signals that focus visitors' attention, suggest how to approach a museum, or how to make effective use of the museum as a learning opportunity.
2. Integrate learning tools for the use of visitors—notebooks, clipboards, measuring devices, prompt sheets, and pictures.
3. Provide learning cues related to overarching concepts or what to pay attention to.
4. Incorporate opportunities for active learning—hands-on exploration of objects and cooperative social experiences.

5. Include labels or cues that prompt students to connect exhibit content with home and school.
6. Provide labels or cues that provide scaffolding of learning to correspond with the age of the visitor.
7. Develop mechanisms that draw on strengths of the diversity of students with special attention to students from non–English language backgrounds and students with disabilities.

Changing a traditional model of instruction can be difficult, as it involves disrupting a status quo and requires staff attention and energies previously allotted to other areas of concern. For this museum, the guided tour program had continued essentially unchanged for many years. Because a large part of docent training focused on gaining scientific knowledge from museum curators, it is not surprising that docents might feel that science (or social studies) content was the most important component of the tour. Furthermore, apparent teacher and student satisfaction with the tours makes instituting change even more difficult. The museum where this study took place is currently reexamining its educational programming, with an ever-growing consciousness about improving the visitor's experience. The museum educators recognize the value of a docent-mediated learning experience for school tours, especially in older halls where exhibit design does not necessarily facilitate learning for school-age children. This investigation was completed in part to inform the museum educators of current conditions and possible solutions. Making changes based on the recommendations described above, however, will require a collaborative effort among educators, teachers and most importantly, the docents.

Given the information provided in this study, we believe that a limited number of formal science standards could complement and enhance informal science programs such as guided tours. We have presented some of these elements in the alternative tour described earlier in this section. We anticipate that museum educators and science educators will use these findings and recommendations to prepare students for a museum visit and help bridge connections among the school curriculum, museum content, and student inquiries. These elements are consistent with the formal science education community, particularly the National Science Teachers Association (1998) and its position on Informal Science Education: The role of informal institutions such as museums should be to "spark curiosity and engage interest in sciences . . . and extends to the affective, cognitive, and social realms" (p. 17). Many of the findings in this study were typical of guided science tour programs reported in the literature where formal didactic teaching behaviors are observed (Cox-Petersen & Pfaffinger, 1998; Griffin & Symington, 1997). Nevertheless, if guided tours at science museums continue to implement didactic, instructor-centered models like the one described in this study, cognitive, affective, and social learning outcomes will be compromised and science learning opportunities may be missed.

Appendix A

Guided Tours Visitation Observation Form: Content and Activities

Codes and Explanation

D: Docent
T: Teacher
S: Student
O: Other

Lecturing (l)—Talk with no direct interaction among students, docents, teacher, or other individual
Interaction (i)—Talk between at least two people that includes asking questions, explaining, making comments about the exhibit, or other on-task behavior
Manipulating (m)—On-task behavior that includes manipulating or touching objects
Observing/Listening (o)—Any noninteractive behavior that includes observing or listening
Management (mg)—Any formal behaviors that include directions, scheduling, discipline
Off Task (ot)—Any behavior that is not related to the exhibit or the content of the tour

Observation Protocol

1. Record a docent, teacher, and student behavior (using codes) every 5 minutes or when an activity changes.
2. Record anecdotal notes beside each code including specific questions or comments asked by docents, teachers, or students and specific on-task or off-task behaviors.
3. Record the number of students that relate to each data code. For example, Si—4 Sot—2
4. As you observe, note information included in the Group Dynamics instrument (e.g., docent sensitivity to ethnicity, gender, age, and language).

Appendix B

Guided Tours Visitation Observation Form: Group Dynamics

Record observations of interactions, comments, and behaviors exhibited by docents, students, and teachers.

Indicators:

Ethnicity (connections to culture, nonstereotypic behavior or comments made during the tour)
Gender (comments are appropriate and attention is given to all students)
Age (discussion and activities are age appropriate)
Language (sheltered-English instruction, connections to students' language)

Appendix C

Teacher Interview Questions

1. Why did you choose to visit the museum?
2. Was it possible to prepare your students for this exhibit? Explain how.
3. Explain how the content of the tour relates to your curriculum.
4. How would you rate today's tour on a scale of 1 to 5 (5 representing the most valuable)?
5. What did you like most about the tour?
6. What did you like least about the tour?
7. What can the museum change to make your visit more relevant to your students?
8. Do you plan to follow up this museum visit with class activities once you return to school? If so, what types of activities will your students be doing?

Appendix D

Student Interview Questions

1. If you were asked to name one big idea from this exhibit, what would it be?
2. Could you name two things that you learned from this museum tour today?
3. Did you like touring the exhibit with a museum guide? Yes or no (Probe: What did you like/dislike about the guide?)
4. What did you like most about the tour?
5. What did you like least about the tour?

Notes

[1]Observation data were coded with specific abbreviations including the data collector's first and last initials, the exhibit observed, and the date (e.g., AC-MB-5/13). Teacher interview data and staff interview data were coded with a unique number and date (e.g., T25.5/7, S4.4/28).

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