Chapter 6
Museum Science Teaching: Museum Educators' Personal Epistemologies and Created Learning Experiences

Jung-Hua Yeh

A report by the Center for Advancement of Informal Science Education (CAISE) described how public engagement with science (PES), in the context of informal science education (ISE), can provide opportunities for public awareness of and participation in science and technology (McCallie et al., 2009). Natural history museums, zoos, botanical gardens, aquaria, and nature centers or parks are well known for informal science education, and they expand possibilities for science learning. In Taiwan, to encourage students' science learning, teachers and administrators from 3-year-old to 15-year-old arrange field trips to such places as science museums or centers. Beyond the expectation of encouraging science learning, science museums offer docent guided tours and educational activities for schoolchildren. Several studies on schoolchildren's field trips have reported that few took advantage of museums' unique offerings (Bartels, Semper, & Bevan, 2010; Bell, Lewenstein, Shouse, & Feder, 2009; Bevan et al., 2010; Falk & Shepard, 2006). Other studies have suggested that docent guided tours tended to appear more as formal learning enacted in an informal setting (Cox-Petersen, Marsh, Kisiel, & Melber, 2003; DeWitt & Storksdieck, 2008; Kisiel, 2005a, b).

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J.-H. Yeh (✉)
National Museum of Natural Science, Taichung, Taiwan
e-mail: jung@mail.nmns.edu.tw

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Introduction of NMNS

The National Museum of Natural Science (NMNS) emerged from the 1970s energy crisis, which prompted the world to place greater importance on the environment. This museum serves as a traditional natural history museum, collecting and investigating natural specimens and anthropological relics. In the area of education, the museum's missions are to raise public knowledge of science, cultivate reasoning and independent thinking, and encourage people's curiosity about natural phenomena. Every year, the museum welcomes nearly two million visitors. The main building and the Botanical Garden have a combined area of 132,132 m^2; the main building includes the Space Theater and Science Center, Life Science Hall, Human Cultures Hall, and Global Environment Hall. Currently, the museum has a staff of 332, including 123 permanent employees (science curators, 55; education curators, 8; technicians and office workers, 60), 127 contracted employees (presenters, 65 and exhibition service staff, 62). NMNS established a volunteer support program in 1986, and the volunteers work in five major areas: visitor services, education, inquiry response, administrative support, and specimen collection, and these areas exclude student groups, corporate groups, and high school student volunteers. As of 2013, the number of volunteers exceeds 1,400.

The employed docents divide into four groups: (1) Commentary, guided tours for groups with scheduled commentary for each exhibition (standard duration, 40 min); (2) Activity, providing hands-on science events in the museum and science-event outreach for primary schools in other cities (standard duration, 40 min); (3) Classroom Theater, 12 small rooms with teaching aids and multimedia that introduce specific, scheduled science topics (standard duration, 40 min); (4) Naturalist Center, a free admission area that provides various all types of specimens and microscopes, allowing visitors to explore nature; it is sometimes reserved by schools to introduce nature events (no more than 90 min).

Although during the past decade in Taiwan, no research has identified the benefits that schools received from guided museum tours, from personal contact with our museum educators, most employed docents in our museum make guided tours as simplified version of science lectures. There is an assumption that the quality of the guided tours could be improved by decreasing the group size as this would lead to an increase in the visitors' concentration. This assumption has meant that most of our employed docents have put efforts into memorizing the notes, which the science curators have provided for the docents in the in-service training. At the NMNS, there are 56 guided school group tours and educational programs on the schedule each. From 2001 to 2006, each guided tour had 45–50 persons per school group (one class counts as one group); since 2011, this number has decreased to only 22–26 persons. The declining birth rate has caused the total number of first graders (6-year-old) in Taiwanese elementary schools to decrease 25% in total every 5 years (National Institute of Educational Resources and Research, 2003, p.118). This means that each guided tour has only half the number of people compared with past years. When observing school groups, I have noticed that before 2006, each group had 8–15 students who paid attention during the group tour; after 2009, however, only 3–5 students have been paying attention. From my observations, decreasing the group size has not enhanced the school children's deep engagement. These observations have led to the development a new education program.

Learning Happens Through Interactions with Exhibitions or People

Since the 1990s, several studies investigated how learning occurs in museums. Falk and Deirking (2000) suggested a context model, that is, museum learning results from interaction among the social, personal, and physical contexts. From interactions between visitors and exhibits, Stocklmayer and Gilbert (2002) proposed the personal awareness of science and technology (PAST) model. Other researchers have grounded their notions about museum learning in constructivism (Russell, 1994; Hein, 1998). They believe that museum learning results from direct (face-to-face) interaction with staff members or indirect interaction (staff members' thoughts manifested through exhibits). The perspective of constructivism for learning considered that conversation (when interacting with exhibits) was evidence of learning, and suggested that museum learning was the collaboration with exhibits (representation of knowledge), identity, and learning environment (Abu-Shumays & Leinhardt, 2002; Leinhardt, Tittle, & Knuston, 2002; Leinhardt & Karen, 2004). These studies affirmed that museum learning occurred while visitors interacted with exhibits, museum staff, or their peers.

In most science museums, docents serve as the point of human contact for visitors, especially for school trips when docents routinely guide student groups through the exhibitions (Cox-Petersen et al., 2003). That which school groups receive from docents is part of their museum learning experience how and what they learn. Most school groups express satisfaction with the docents' guided tours, but do not see the field trip as a learning experience (Cox-Petersen et al., 2003; Davidson, Passmore, & Anderson, 2010; Kisiel, 2010). Some researchers advised educators (docents and teachers) to meet and prepare prior to field trips, to build a bridge between school science and science museum exhibitions (Davidson et al., 2010; Jarvis & Pell, 2005; Kisiel, 2010; Tal, Bamberger, & Morag, 2005). Davidson et al. (2010) and Patrick, Matthews, and Tunnicliffe (2011) highlighted the influence that teachers who involved themselves in pre-visit preparations had on students' awareness of learning. Cox-Petersen et al. (2003), Kisiel (2010), and Tran (2007) suggested that docents' pedagogy and their goal for science learning contributed to students' learning. These studies concluded that the docent's personal interest in science and their museum-learning experience diversified their teaching practices.

Social Identity, Personal Science Epistemology, and Staff–Visitor Interaction

After the mid-20th century, simple tests inquired about how people separate their identity from others (Kuhn, 1960; Zurcher, 1977). In this research, the identity of self included the physical self (physiological features), social self (a particular social position or status), reflexive self (personal characteristics or personality description), and oceanic self (global statements that fail to differentiate oneself from others). As an important index, the social self helps individuals behave correctly according to their social category. Social identification includes two processes: self-categorization and social comparison, which are context dependent. The interaction contexts could highlight one social category over others or as an underdog, and the same social category might be reversed in another context (Abrams, 1999). For example, employed docents in a science museum clearly know that they are not scientists and they have lower status than the science curators in discussing scientific knowledge; however, docents believe they have much more information about the science exhibits than visitors. The docents are the main source of information for visitors to the guided tours; therefore, the docents have higher status than the visitors. Several studies have stated that guided tours can be didactic and lecture-oriented or exciting and engaging, depending on how docents view themselves (Ash, Lombana, & Alcala, 2012; Kisiel, 2010; Tran, 2007, 2008). Tran suggested that docents with personal interest in science can introduce much creativity, complexity, and skill in teaching science; however, they also need to connect the museum's educational agenda with school science curricula and treat school visits as part of a long-term science learning experience. Several studies have argued that students felt that they gained no learning during museum visits because docents were not concerned about the connection between the exhibits and school science courses (Cox-Petersen et al., 2003; Davidson et al., 2010; Kisiel, 2010). Ash et al. (2012) found that science museum docents could change their practice by transforming their social identity from that of a one-way presenter into an educator. These studies found that how docents' perceive their identity in teaching science affects their pedagogy.

The identity to which Ash et al. (2012) and Kisiel (2010) referred is how docents approach their role in guided tours and as an educator. Neither study described how one identifies an educator's duty.

The present research drew on a personal science epistemology approach to interpret docents' identity in museum education, including how they think about science and what they think is important for teaching and learning science (Hofer, 2004). According to social identity theory, docents choose their teaching material based on their science-teaching role, which then shapes their pedagogical practices. When interacting with a docent, schoolchildren receive their museum experience through that docent's specific pedagogy. A docent-science educator needs to define important science events (knowledge) and methods of teaching science (knowing).

These individual beliefs about knowledge and knowing are the docent's personal epistemology.

During the last two decades, many studies on personal epistemology have addressed the theories and beliefs individuals hold about knowledge, and how such epistemological perspectives are related to academic learning (Hofer, 2004; Hofer & Pintrich, 1997; Schommer, 1990; Schommer-Aikins 2002). Schommer (1990) suggested that in different domains, personal epistemologies might be independent of each other. Furthermore, Hofer and Pintrich (1997) provided a quasi-theory framework for personal epistemologies in different domains. Hofer (2004) examined first-year college students for domain-specific personal epistemologies in the context of introductory chemistry, revealing how personal epistemologies influenced students' perception and learning behaviors and how their epistemologies kept changing during academic learning. Personal science epistemology may be ascertained from the following dimensions of scientific knowledge: its stability, structure, source, speed of its acquisition, and control of its acquisition (Schommer, 1990). Personal science epistemology is a multi-belief, complex system, each dimension is somehow independent of the others, evolving and changing according to personal experience (Schommer, 1994). Examining an aquarium staff's collaboration with an elementary school, Kisiel (2010) found that the collaboration raised staff members' understanding of the classroom setting and teaching as a career. Ash et al. (2012) provided evidence that changing how explainers viewed their identity caused changes in their practice. Therefore, this study reveals how social identity and personal science epistemology lead to differing science instruction.

Methods

This study drew upon qualitative approach to inquire two senior docents' self-identity, personal epistemology, and pedagogical practice. These two docents patriciate an activity which expected to help teenagers learning by objects. The study combined observations of the docents' preparation process, practice teaching, and interviews to provide multiple evidentiary sources and data triangulation.

Methodological Framework: Case Study Approach

The framework for this research uses a case study method (Stake, 1995; Yin, 1989). Yin noted that case studies are advantageous approaches to research projects that address explanatory and/or descriptive questions in a real-life context; they are particularly appropriate when the researcher has no control over events. A case study's goal is not to provide generalizable results, but to reflect on museum education practice through the perspective of personal science epistemology. This case study draws on interviews, observations, and pedagogical artifacts to develop an interpretative understanding of the relationship between museum practice and docents' beliefs.

The two participating docents were in their tenth year of museum work at a mid-scale natural history museum. Mei (pseudonym, female) is an employed museum presenter, and Yan (pseudonym, male) is a volunteer. They enrolled in a task force to develop inquiry-based learning activities for school tours. They both earned credit for their routine work in the museum and for participating in the study.

Mei is an experienced presenter in the National Museum of Natural Science (NMNS). She began her career at the museum almost 20 years ago. She had taken guide tour for zoology, archeology, and biodiversity, despite having earned her college degree in applied science. She gained her knowledge of various scientific subjects from the museum's science topics commentary training.

In 1992, Yan joined the museum's learning sheet task force as a volunteer. He is an experienced science teacher and active instructor for the pre-service teacher training program at his school. Having earned a college degree in earth science, Yan taught 8th grade physics and earth science. In 2002, he retired as dean of a downtown public junior high school, continued his voluntary participation at the museum.

This study also considered audience opinions. Sixty-six students participated in the study. Of these 66 students, all were in their first semester of 7th grade at a medium sized municipal senior high school in Taichung City, which they had entered directly from elementary schools in nearby school districts. There were 26 females and 40 males in the study, with an average age of 13.5 years. The ethnic background of the students represented a cross-section of the high school, with 64 Taiwanese and 2 Taiwanese Indians. The students were in two classes, but they had the same science teacher. This high school is a partner school to NMNS and is a 10 min walk to the museum. About once a month, the 7th grade science teacher brought the students to the NMNS, where they participated in a 2 h science class in the Exhibition Halls. These students came to the museum to participate in education programs, such as speeches, demonstrations, guided tours, and new educational program tryouts.

Observations

This paper primarily focuses on the two docents' teaching plans, which provided high contrast in terms of underlying epistemological assumptions. Observations were centered on teaching goals for museum learning, organization of learning material, importance of specimens in teaching, and role of the educator. An observational study is shaped by a particular purpose that guides what is obtained and how such information is used. My primary goal in these observations was to examine how beliefs about knowledge and knowing are communicated in the museum program and how they are situated in teaching behaviors.

The observations offered rich understanding of how the docents prepared their guided tours so that interview questions could be contextualized within common practice. Observational notes were written as running field notes. In addition, the pedagogical artifacts docents prepared, such as the fragments of implements or potteries came from archaeological findings which they used in teaching, PowerPoint introductory presentations, and photos were collected. The written field notes were interpreted, in accordance with the dimensions of epistemology identified in an earlier literature review (Hofer & Pintrich, 1997), by identifying examples of practices and incidents that might be classified as indicative of simple knowledge, certain knowledge, the source of knowledge, or justification for knowing. A discussion with docents of such situated practices furnished a potentially contextualized, phenomenological understanding of their personal epistemology.

Interviews

The docents were interviewed at three points: after a lecture, after their teaching plans were presented, and after a session of practice teaching. The interviews used open-ended questions that provided a framework and were guided by an interest in hearing individuals "use their own words to express their personal perspectives" (Patton, 1990, p. 277). The semi-structured interview protocols included questions that explored general personal epistemology through questions adapted from existing interview protocols that tapped the four dimensions suggested in the literature (Hofer, 2001), and questions, pertinent to instructional practices, that docents answered after their practice teaching.

Analytical Process

Early analysis of the observational notes provided incidents and topics for interview questions; accordingly, the observations were read for suggested evidence of the four hypothesized dimensions of personal epistemology. Interview analysis was an ongoing, iterative process, facilitated by note taking at several points. To begin the coding process, each question on the three interview protocols for the dimension(s) guided the writing of the questions. For example, a question about how a docent thinks of archeological practices was hypothetically coded as "simplicity of knowledge."

The practice teaching was video-recorded and the audio portions were transcribed according to time spent on each learning experience. The duration of different teaching behaviors were calculated based on the different learning experiences. Periods of talking, student discussions, and specimen observations were calculated, respectively. The percentage of time spent on student discussions and specimen observations could be an index of how the docent's personal science epistemology affects the pedagogy. These videos of test teaching were also coded by episode to clarify the following: whether the docent treated the specimen as a source of research data or academic evidence; whether the docent thought learning occurred during discussion or listening; and the docent's assumed identity during the exploration activity.

The final methodological step was to consider issues of verification. I employed "member checking" (Creswell, 1998; Stake, 1995), an accepted means of establishing credibility in a qualitative study, by providing an early draft of this paper to the participating docents.

Study Background

Since the NMNS Life Science Hall opened in 1988, the science education curator has planned in-service training for experienced science teachers to develop learning sheets for primary and secondary school students. Teachers involved in the learning sheet task force met regularly with the education curator and brought their students to the museum to test the new learning sheets. They voluntarily participated and could discontinue at any time. Until 2002, this group consisted of about 15–20 teachers per year and produced 20 learning sheets for 12 different exhibition galleries. Each permanent exhibition gallery had at least one learning sheet, and the museum planned to renew some exhibition galleries that had been open for over 10 years.

In 2002, according to educational statistics announced by the Republic of China's Ministry of Education, the number of first graders would decrease by 50% every 5 years. Faced with the impact of a low birth rate and the competition from Internet science learning resources, the museum's department of science education tried to create new attractions for visitors, especially school groups. In 2009, the task force for editing the learning sheets changed goals to develop a "new exploration program," and only five experienced science teachers remained. While attempting to develop this new program, after discussions with these five teachers, we reached consensus that the program would adapt these approaches: learning occurring through interaction, staff as facilitators of learning, and learning from objects.

Based on constructivism, this exploration program would implement the notions of "learning from the object" and "learning by the visitor-self." In Taiwan, visitors highly rely on the docents' guided tours to learn about the exhibition galleries, and the new program developers hoped that the docents would act as facilitators to encourage learners' observations and reasoning. Because the employed docents would conduct the new exploration program, they were invited to engage in the development process.

Development Process

During the exploration program development, we requested that the collection managers help find educational materials for the program. The archeology department provided some artifacts from three different sites in central Taiwan: Niu-ma-tou (middle Neolithic, BC 3700–BC 3500), Ying-Pu (late Neolithic, BC3500–BC2000), and Fanzaiyuan (late Iron age—AC 400). Most of these were small pieces of broken pottery, but some were made of stone, and all were left safely untreated with any toxic chemical solution. Visitors were allowed to touch all these artifacts, which thus became direct evidence for constructing knowledge, because different ages of pottery are easily recognized through the sense of touch. After the pottery was provided, I showed it to the learning-sheet editor/teachers and the employed docents, inviting them to engage in developing a new exploration activity. Yan responded to my invitation immediately, and Mei joined us later.

During the six-month research period, I observed how the docents interacted with the pedagogical and archeological museum staff, how they prepared the topic, how they chose teaching materials, and their practice teaching. For the first four weeks, we met once a week to introduce inquiry-based learning and teaching. For the next four weeks, the archeology curator lectured on the three pre-historical archeology sites studied by museum archeological staff, and then for two weeks, we visited the archeology studio. After these preparations, Yan provided his teaching plan, and we arranged three sessions of practice teaching and post-teaching discussions. In those meetings, Mei approved the plan as "excellent," but her practice teaching drew on a totally different plan. In the post-teaching discussion, Mei claimed that she could not implement Yan's teaching plan. Each practice teaching was video recorded and transcribed by the minute.

Results

According to models of personal epistemology, all data analysis suggests that individual theories about knowledge and knowing comprised multiple dimensions that can each be expressed as a continuum (Hofer & Pintrich, 1997). In addition, personal epistemology's dimensions clustered into two central areas: (1) the *nature of knowledge* or what one believes is knowledge is. The nature of knowledge includes two dimensions: certainty of knowledge [a progression from believing that absolute truth exists with certainty to the position that knowledge is tentative and evolving] and simplicity of knowledge [viewing knowledge as an accumulation of facts to seeing knowledge as highly interrelated concepts] (Schommer, 1990). (2) The *nature or process of knowing* or how one comes to know. (1) The nature of knowing consists of the knowledge perceived and the justification for knowing. The source of the knowledge perceived originates outside the self and resides in external authority or is constructed by individuals in interaction with the environment and others. Justification for knowing is how individuals justify what they know and how they evaluate their own knowledge and that of others (King & Kitchener, 1994). This analysis is not focused on profiling participants' personal science epistemology, but aims at examining their practice from the cross-section of personal science epistemology.

Personal Science Epistemology Reflected in the Learning Process

Both docents verbally agreed on the social constructivism perspective for learning, which the science education curator introduced in the regular meetings. They also agreed that the events they guided in the museum were for education; their role in the museum was that of an educator:

Mei	I think the teachers who reserve the educational program have the purpose of education, not entertainment. They (the students) came into the museum with the expectation of obtaining much more knowledge. My duty is to give them enough and correct knowledge. Just like the teacher in school, the docent and the teacher are educators.
R (researcher)	What do you mean "correct" knowledge?
Mei	The lectures in the museum provide us scientific knowledge reviewed by those "doctors" [curators] in science departments. They [curators] are careful and professional in science. That knowledge would not go wrong.
R	Do you think that "correct knowledge" needs to be renewed, and sometimes the science curator might not catch on?
Mei	Yes, science is progressing. We don't show things as uncertain in the education program. Those science curators provide the "truth" that all scientists agree on for us to teach in the museum.

This interview quotation reveals that Mei felt that science knowledge as "static" came from the scientist, and the scientist provided all things for learning. However, Yan reflected from his teaching experience:

Yan	The role of docent is as the teacher in the museum. But there is not a certain concrete content knowledge that should fill in each program hour. We could do much differently from school science.
R	How is that?
Yan	People have different expectations for school, after-school tutorial classes, and the museum. You don't expect to visit a science museum today and get A++ for a science test tomorrow. Students come to the science museum to see some different aspects of science; those who do not adapt to examination and seem interesting. Or they hope to know how "to do science." We can give students much opportunity to observe, think, and reason.
R	What do you mean, "To do science"?
Yan	Things that adults want students to keep in their memory exist only in the science classroom. Science knowledge is changing. I mean most science information renews every few years. They [students] aren't interested in it,

> and they do not understand it, really. Things meaningful to students are those they are interested in, can talk to, and are used in life. I don't mean to expect students to act like scientists. But they need to have a chance to connect the hypothesis, observation, and reasoning. Scientists producing knowledge also repeat this process. In my opinion, the science process is much important than scientific facts.

Yan believed that the museum should provide different aspects of learning from those provided by schools. He emphasized the process of making knowledge: he saw students' interaction with peers as a useful path for science learning. Yan felt that although scientific knowledge is changing, the schools focused on merely feeding students more information. Thus, most important for the museum was creating a different learning experience for the students.

Mei enjoyed the curator's lecture much more than the educational issues discussion. In the archeology lectures, Mei busily wrote notes, whereas Yan jotted down just a few words. Mei felt that in the first lecture, the archeology curator gave a very clear picture of the three archeological ages. And the next three lectures featured related research in other Taiwanese locations. After each lecture, Mei asked the curator to provide her several photos to use as teaching materials. She felt that the curator had provided a full introductory vision of archeology.

> The curator is very nice. He provided much knowledge about archeology. And there are lots of photos of pottery in different ages; they are good to use in teaching. His lecture was very useful to help me prepare for teaching.

After the first lecture, Yan came to the interview with some references about these archeological sites and asked for leave to miss the next three lectures.

> The lecture provided several keywords for the three archeological layers. And I found these references [some seminar proceedings, journal papers]. These are from creditable sources. It is enough for me to design a teaching plan. And… [personal reason for leave for the next three weeks].

Obviously, these two docents favored different learning processes. Yan was an active learner who recognizes key concepts and tries to find more information by himself. Mei relied on authority to provide information. Both docents were present in the archeology studio visit and interacted with the staff there. Mei listened to the introduction carefully and asked questions to ensure that she had noted all the details about how to process the artifacts—washing, drying, marking, documenting, and categorizing. Yan observed the three piles of artifacts from the three different archeological layers. He asked questions to understand how archeologists construct knowledge from specimens, but the staff could not answer most of his questions. During the second studio visit, an archeology curator made a presentation and deeply discussed with Yan how the artifacts supported forming a supposition and how further relics provided proof or disproof.

Teaching Goals

During their preparations, Mei and Yan presented different and interesting plans. Mei focused on how to conduct archeological excavations. Yan focused on how the archeologist constructs knowledge from artifacts. Their designs for the education program reflected their differing interests.

> There is too much content knowledge fed to students in school science. I think the museum should provide a different style of learning. The education program should give many chances for observing, thinking, and reasoning. We have a good topic. These archeology sites are located around the city, most students have heard about them. They would be interested. And things from three different archeological layers could provide the chance to distinguish objects according to age, their function, and then help restructure life in that age. The best thing is when children do these explorations, they don't have to use expensive equipment. The experience is directly from their fingertips and about past life appliances.

Yan presented the education program's goal very clearly, and he aimed at engaging students in the process of doing science. Mei did not present her idea for the education program. She said that Yan's idea was good and fit for the museum's situation. She mentioned in the meeting that we should include more information for archeological excavation. But according to her interview, she cared very much about the quantity of knowledge provided in the education program.

Mei I think the teachers who reserve the educational program have the purpose of education, not entertainment. They (the students) came in the museum with expectation of obtaining much more knowledge. My duty is to give them correct and enough knowledge. Just like the teacher in school, the docent and teacher are educators.

She emphasized providing scientific knowledge correctly (quality) and amply (quantity), but she did not clearly state her overall goal.

Teaching Plans and Materials

Yan's proposal included two activities, both using real archeological pottery as material for inquiry. The first set of pottery included three pieces that came from three different archeological layers. His activity was a closed-end inquiry that asked visitors to classify the pottery's age by touch. The second activity provided each group a set of artifacts and asked visitors to guess how people lived at that time, according to the specimens they had. The ending was a summary that focused on reflective thinking during the process. Yan's teaching plan is presented as Table 6.1.

After Yan's second practice teaching, Mei claimed in the group meeting that she had another idea about the topic. Mei's proposal was an outline of an introduction to archeology, with, as she asserted, some inquiry factors in the process. Mei's

Table 6.1 Yan's teaching plan

Time estimate (min)	Teaching protocol	Personal science epistemology attribution	Pedagogic concern
1	Students assigned in 3–5 persons group	Knowledge came from personal exploration and peer interaction	Learner center
1	Brief introduction the concept of archeological layer and age		Operational principle
10	Sorting the 3-piece potteries by their archeological layer	Application of knowledge from authority	Practice
10	Group reported their answer Docent response	Justification for knowing through the evaluation of evidence	Docent as facilitator to enhance the dialog between groups with different answers
15	Each group had one set of heritage Each group needs to predict which archeological layer they belong to and provide an assumption for the life of that age	Source of knowledge as actively constructed by individuals in interaction with the environment and others Simplicity of knowledge by seeing knowledge as highly interrelated concepts	Docent as facilitator to enhance the in-group fruitful conversation
20	Group report Docent response	Justification for knowing through the evaluation of evidence	To remind students to recheck their conclusion according on their specimen
1	Conclusion		

teaching plan is presented in Table 6.2 and shows she used lecture with no exploration activities. We asked her to include some exploration opportunities. She replied that she would find some questions to lead students' thinking and reasoning during her practice teaching.

Table 6.2 Mei's teaching plan

Time estimate (min)	Teaching protocol	Personal science epistemology attribution	Pedagogic concern
10	Explaining the concept of archeological layer	Source of knowledge comes from external authority	Docent as the representation of the expert
15	Introduction how to research the archeological site		
25	Explaining the standard operation procedures of the archeology heritages taken from the archeological studio		
5	Show students the heritages from three different archeological layers	Justification for knowing by the assessment and integration of the views of experts	

Roles of Teachers, Learners, and Objects

Figure 6.1 displays a comparison of the two docents' teaching behaviors during practice teaching. Mei taught in lecture style, employing many photos of the archeological excavation process. Yan spent more than 80% of the time on students' observations, discussions, and communications of their different ideas.

In the post-teaching meeting, both docents gave reasons for their behavior. Mei thought her plan provided adequate knowledge to satisfy seventh-graders' expectations. And she also had some comments about Yan's teaching:

> I've watched [on the video-recording] his teaching twice. And I don't understand what he wants to give to students. The students' discussion wasted too much time. After the program, students know no more archeology than before. We should offer more knowledge to students. I did not know what the teacher should do when the students discussed or did not discuss.

Mei believed lecturing is the most efficient teaching method. To make students concentrate and engage, she had them answer questions she had mentioned earlier. According to observations of the practice teaching, Mei viewed the docent's role in teaching as being the source of knowledge. She believed that students could not obtain knowledge from discussion and observation; they could accept academic knowledge only by listening. In her teaching, the student was a passive receptor, and she believed that was best. In Mei's teaching, the objects were decorative.

> The specimens of archeology are rarely seen in other places. They are good for attracting schools to reserve this program. The pottery could make the students feel real knowledge

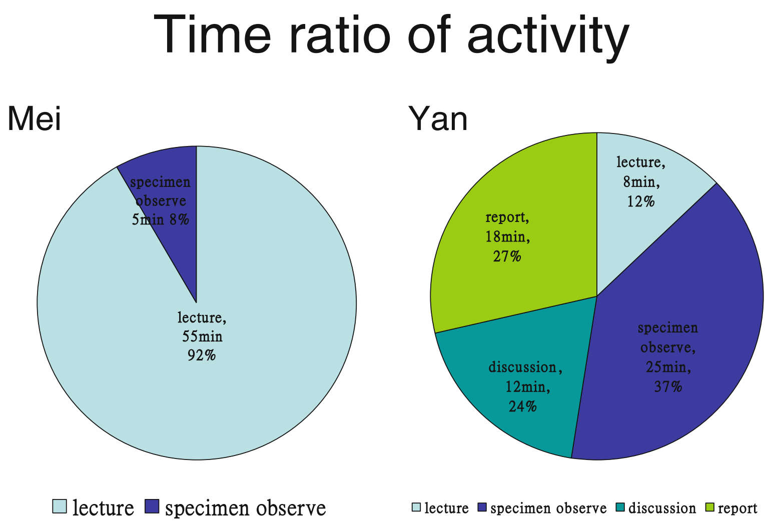

Fig. 6.1 Percentages of time allotted to activities in each docent's teaching plan

introduction in the program. They are not archeologists it is impossible for them to gain any knowledge from observing those potteries.

Mei felt that the museum's education program should use real objects to attract visitors and that the artifacts' reality and age would interest laypersons. But the specimens did not play a leading role in her teaching; instead, they ornamented her program's conclusion. Yan respected Mei's choice. He said that it was usual for educators to have different pedagogical practices. But he also said he came to the museum to implement authentic learning:

We need something different from school science that could help the public understand there is another choice in learning science. It looked like a waste of time to let the students observe and discuss. But they could get the spirit of science from the process. Though the result is rough, needs more evidence and examining, the program creates a new trial for museum science learning.
There are two leading roles in my teaching, the students and the objects. I gave students simple guiding, and they applied it in the first activity. They could find achievement in it, and feel that knowledge could be manipulated. Then mind engages in what is possible. The object is the second lead. It acts as evidence to produce knowledge, on the one hand, and is novel to arouse curiosity.

Yan did not cast himself in the program's leading role. Instead, he acted as a facilitator. During the students' group discussions, he hung around between the groups and encouraged students to express their arguments. In this manner, the students became the center of the program. Yan supposed that the students were active learners and that the objects provided a ground for constructing knowledge, thus becoming both evidence and attraction.

Students' Feedback

Two classes (N = 66) of seventh-graders participated in the practice teaching, and both classes took both Mei's and Yan's programs. One class (Class A, 33 students) took Yan's program first and then Mei's; the other class (Class B, 33 students) first took Mei's program and then Yan's. The teachers collected the students' after-visit diaries, and all 66 reported interest and positive responses to both programs.

Yan's program made a deep impression on the Class A students, with thirteen of them mentioning that they were excited to access the artifacts and try to do an archeologist's job.

The program made us experience what the archeologist does. It's the first time I feel myself that I could take a scientist's job. The program made me feel interested in how the archeologist found these potteries. I was very attentive in the second section. (Student A02)

Although the Class A students said that they were attentive during Mei's program, there was no further description about Mei's teaching, content, or photos. Of the Class A diaries, 9 mentioned that Mei's program introduced the process of archeological excavation and 5 of them felt that excavation was a difficult job.

Typical feedback of two types came from Class B (Mei's program first): The first program was a little bit boring, and the second one was interesting; they mentioned their actual experience only in Yan's program:

> The first session was the same as a history lecture in school. There were lots of photos to show how to do archeological excavation. The second one was really funny. He [Docent Yan] gave us some pottery, and we had lots of time to discuss. The questions in the program needed to be answered according to our evidence [pottery]. The docent did not pronounce our answer as right or wrong. He showed us the principle to check whether we needed to fix our answer. (Student B29)

This quotation reveals the student's feelings about the two programs. Mei's program seemed very similar to school and Yan's program engaged them in the process of learning.

> It was interesting. I accessed more archeology things in the second program. I have not taken a program like this before. We did a similar process with a scientist. I enjoyed in the program. (Student B03)

Most of the students' diary entries resembled that quoted above. Of the 33 students in Class B, 12 commented positively on the visit and wrote much related to Yan's program. There were 11 students (Class B) mentioned both programs, the first as an introduction to archeology and the second as a hands-on activity. The other 9 diaries (Class B) mentioned only the second program: Yan's program had student discussion, observation of artifacts, forming hypotheses as an archeologist. In Class B, 8 diaries had detailed descriptions about the process and content of the whole process of this visit but the descriptions of Yan's program contained much detail.

> This visit included two programs. The first one was an introductory lecture of archeology. The second one was an activity to experience what archeologists do to the things they dig out. The docent asked us questions, and we needed to answer according to the artifacts we had. At the beginning, we felt nervous because we were not good at archeology. The docent suggested to notice some differences between the things, and soon we knew how to answer. This was the first I felt the time went so fast in a museum program. (Student B19)

The 8 Class B diaries all included a brief description of the two programs, deep impressions of the docents, and their positive emotions toward the program. They were most impressed with Yan coaching them on how to develop their argumentation during the discussion, and reminding them that their report of reasoning should align with the evidence (artifacts) in the feedback.

Reflections from the Docents

At the last education meeting with the two docents, we read these diaries together. Before the meeting, I selected diaries that described the visit with at least a completed paragraph.

Yan was excited because the students liked his exploratory approach, but mentioned room for improvement:

> I am glad to know students liked this program. And most of them felt they had done the things archeologists do. In the program, it is necessary to supplement some materials to quickly introduce how we get these potteries.

On the other hand, Mei felt frustration and a little anger that few students had talked about her teaching. She attributed this to Yan's program being akin to a game with activities; children would rather play than learn:

> I chose a good topic and organized the content well and so many photos to help them know all the details about how archeologists work. They preferred to play rather than to learn. If the test teachings were separate at different dates and the students were independent, they would show how deep their impressions were for this content.

Mei noticed that most students did not express any understanding about the archeological layers or sites introduced in both programs. She believed that although most students liked Yan's teaching, no effective learning occurred.

> Though I have watched his teaching [video] 3 times, I see no learning happening. If we created a test for the ages of the three archeological layers, the locations of the site, and the difference of the life style, my program could help them to get higher scores than yours [Yan's].
> How can you (the education curator) accept his program as an education program? It teaches nothing to the students. The activities are vivid and novel for the museum, but teachers expected us to bring them more knowledge. We should not have spent almost 1 h on the scientist role-playing game.

Mei cared very much for the quantity of knowledge, and her criterion for successful learning was a paper-pencil test for recalling terminology. This might be a limitation of her personal science epistemology. Mei believed that knowledge comes from scientists, and only scientists can judge what is important in the field of science. In this meeting, she argued with Yan about whether students could learn from discussion, believing that the discussion's educational function is to evaluate or apply previously learned concepts. And she felt it strange that Yan's program promoted the students' interest in her program.

Mei How can they learn from discussion? They know nothing about archeology; it is impossible for them to discuss and provide an answer.

Yan There are two durations for discussion in the program. Before the first, I explained the concept of archeological layers and provided them a simple principle—the better controlled the fire, the finer the pottery feels. They adapted the principle in predicting the age very well.

Mei Yes, the first discussion is the evaluation of the concept of archeological layers. But they are not archeologists. How could you ask them to recover life in that age? Their conclusions must be wrong.

Yan While they were discussing, I heard them guessing each piece pottery as what kind of tackle. And they knew the characteristics of the Stone Age, Neolithic, and Iron Ages in school, so they are capable of making a reasonable guess.

Mei How can students get anything from talking to each other? There is no expert in their group.

Yan I think the learning did happen when they made their reasoning agree on the artifacts they had. Students got the chance to practice the process skills of science. During the program, they observed, reasoned, and provided hypotheses. If we aroused their interest in archeology, they could open the computer and Google some keywords which they learned from the program.

Conclusion

During the conversations, we found that the two docents had different educational goals. Although they both identified their role as that of an educator, their criteria for good education differed. Mei insisted that acquiring academic content knowledge is the core goal for a learning program. Yan wanted to provide students a chance to practice science process skills; his goal focused not just on emotion, but also on the experience of doing science. In Yan's program, discussion served to inspire learning; Mei's program treats discussion as evaluation or application for concepts the learner has gained in the lesson. Because Mei believed the appropriate way to receive knowledge was from authority and the scientist was the authority, in the museum (or classroom), the docent (or teacher) should be the scientist's representative. Yan's personal science epistemology about the source of knowledge came from interaction with persons or the environment, and he believed that discussion among peers could offer positive learning experiences.

Discussion

The research finding presented two docents who had different personal science epistemologies, which led to different decisions about their pedagogy practice. They study revealed the fact that docent embedded different personal science epistemologies with different practices. On the point of view of the science museum, we need to take into consideration the value of different epistemological beliefs and pedagogical practices. Schommer (1990) stated that personal science epistemology is a kind of belief system. Belief is rooted deeply in one's mind and difficult to change. According on these findings, the discussion paid attention on the value of two different pedagogical practices and how to have the docents capable to appreciate the practice which based on different personal science epistemology.

The Mission of Science Museum

The introduction of NMNS stated that "the museum's missions are to raise public knowledge of science, cultivate reasoning and independent thinking and encourage people's curiosity of natural phenomena". Education is one of the human activities in society. The thought of quality for education is changing from passive accepting to active engaging. In the 1990s, there was a debate for "presenting science as production or as process" in science museum (Aronld, 1996; Morton, 1997). The viewpoint of "presenting science as a production" is easy to find significance objects for collection, and these advanced science findings implicated in objects also quick step into "outdated science". A science museum conveys its mission of education could taking the role as a new information provider or sharing the sense that science as a process with visitors. The science museum practice often take the role as information provider. Yan's program provides a choice: to facilitate learners reappear the process of science knowledge product. The program of Yan includes the personal science epistemology vision: knowledge is tentative and evolving; knowledge embedded in interaction with peers or environment; knowledge is interrelated rather than discrete piece; and individuals justify what they know through observation. These science epistemological believes are rare appearing in school science. And Yan integrated his personal science epistemology in pedagogy by these events: group discussion, open end learning task, finding answer from observation, treating students' misconception as the start point of learning and response by answers come from evidence reasonable. This case provided an opportunity for learners to access science argument in a short period.

The Professional Development for Docents

Though Schommer (1990) referred to personal science epistemology as belief and hard to change. Some studies found that students' personal science epistemology during academic training changed (Hofer, 2001; Tsai, 2008). Brownlee and Berthelsen (2005, 2008) made an elaboration for the correspondence between personal epistemology and pedagogical practice, and confirmed the contributions to help teachers reflective their pedagogy on personal epistemology. In this research, Mei could not agree there was learning taking place in Yan's program because of the her strong personal science epistemology: science knowledge comes from the scientists only (students could not acquire science knowledge by peer discussion); science knowledge is independent in different field (there are no connection between chemistry, physic, biology and archaeology); only the authority could judge whether you get knowledge or not (all teaching material should organize by science curators). Mei's practice was typical case of science museum learning activity.

Brownlee and Berthelsen (2008) presented a view of learning in relation to change in epistemological beliefs drawing on the 3 P Model of Learning (Personal presage factors, Perceptions of the environment-personal epistemological socially constructed, and situational presage factors) proposed by Biggs (1993), and suggested a model for relational pedagogy that is socially and contextually situated which tried to extend teacher's vision of personal epistemology by pedagogical practice. Brownlee and Berthelsen (2008) referred to change in teachers' thinking about their practice is required by the increasing recognition that teaching is a complex and multifaceted process, teacher education courses need to stimulate reflective and critical thinking about practice as necessary preconditions for effective learning outcomes. It is useful for the professional development of docent.

Ash et al. (2012) drew on the sociocultural frameworks, followed the idea of zone of proximal development (Vygotsky, 1987) to promote docents' capable to scaffolding in their teaching. Allen and Crowley (2014) offered case studies which explored how part-time museum docents engaged in reflective practice through iterative implementation and some of their approaches to learning and teaching in the museum changed. Both research ground on sociocultural frameworks and sent their docent professional development practice through the theory of situated learning (Lave & Wenger, 1991). It looks a potential training framework for museum educators. And Ash et al. (2012) drew on the scaffolding in the zone of proximal development; their work provided a much clear framework to enable docent changing their practice. We will follow the same framework to improve the professional development of our employ docents and examining whether they would accept the parallel personal science epistemology in practice.

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