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"Wow! Look at That!": Discourse as a Means to Improve Teachers' Science Content Learning in Informal Science Institutions

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Abstract Currently, it is not clear whether professional development staff at Informal Science Institutions (ISIs) are considering the way exhibits contribute to the social aspects of learning as described by the contextual model of learning (CML) (Falk & Dierking in The museum experience. Whalesback, Washington, 1992; Learning from museums: visitor experiences and the making of meaning. Altamira Press, New York, 2000) and recommended in the reform documents (see Cox-Peterson et al. in Journal of Research in Science Teaching 40:200–218, 2003). In order to move beyond only preparing science teachers for field trips, while necessary, it is also important to understand the role exhibits play in influencing teachers' content-related social interactions while engaged in ISI professional development. This study looked at a life science course that was offered at and taught by education staff of a large science and technology museum located in the Midwest, USA. The course was offered to three sections of teachers throughout the school year and met six times for a full day. The courses met approximately once a month from September through the beginning of June and provided 42 contact hours overall. Elementary and middle school teachers ($n = 94$) were audio- and videotaped while participating in the content courses and interacting with the museum's exhibits. When considering the

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two factors within the sociocultural context of CML: within-group sociocultural mediation and facilitated mediation by others, the use of exhibits during both courses generally did not fully take into account these elements. In this study, it seemed that teachers' talk always had a purpose but it is argued that it did not always have a direction or connection to the desired content or exhibit. When freely exploring the museum, teachers often purely reacted to the display itself or the novelty of it. However, when PD staff made explicit connections between exhibits, content, and activities, participants were more likely to be involved in in-depth, content-related and pedagogical conversations while engaged in the course.

Keywords Professional development · In-service science teacher education · Informal learning environments · Science education

Introduction

When visiting an Informal Science Institution (ISI) and its exhibits and exhibitions, social interactions are often noted as being imperative for the learning of presented content (Martin, 2004) and visitor conversations are encouraged (King, 2006; Tran, 2007). In general, "meaning emerges in the interplay between individuals acting in social contexts and the mediators—tools, talk, signs, and symbols systems" (Schauble, Leinhardt, & Martin, 1997). This is especially the case when addressing the general visitor. However, Martin (2004) raised questions concerning teachers and how they constructed learning activities in informal environments; how teachers might respond to professional development workshops in informal learning environments; and how the physical exhibit may impact talk and concept development through its very design.

Further, in order to address the unique learning environments ISIs provide, Falk and Dierking (1992, 2000) introduced the contextual model of learning (CML) as a way to organize the complexities of learning within an informal science setting. This is a large-scale framework through which the authors are trying to tap into an individual's personal, sociocultural, and physical contexts over time. The focus of this study is on the sociocultural context, and the following explanation is provided by Kisiel (2003, p. 3):

- Within-group Sociocultural Mediation
  - Museums are uniquely suited for social learning; visitors in groups utilize each other as vehicles for reinforcing beliefs and making meaning.
- Facilitated Mediation by Others
  - Museum staff and other visitors can impact individual meaning.

The sociocultural context of CML also takes into account Vygotsky's (1978) ideas regarding the social aspects of learning. Falk and Dierking (2000) state "learning is both an individual and a group experience" and one cannot "analyse individual processes to understand social processes, … in order to understand the

individual, one must first understand the individual's social relationships" (p. 43). Further, it is claimed, "verbal and non-verbal social interaction plays a critical role in supporting learning" in ISIs (Fenichel & Schweingruber, 2010, p. 14). In addition, Hein and Alexander (1998) addressed the constructivist nature of museums and noted the social process of learning as being important to consider for these learning environments.

For example, in an exploratory study conducted by Stevens and Hall (1997) about an exhibit titled *Tornado* at the Exploratorium, they supported other studies (e.g., Falk & Dierking, 1992) finding that little inquiry learning happens beyond the concrete (i.e., "what is it?") and never ventured into the abstract (i.e., "what are the principles involved?"). Further, the interactions were at the level of "effects" instead of explanations and understanding (Stevenson, 1991). The exhibit did not extend visitors' understanding of content due to its implicit treatment of the topic.

During the study, the researchers videotaped visitors' interactions with the exhibit, which included a 15-foot cylinder with a water vapor vortex inside that mimics an actual tornado (although inverted). The tapes were then used as a focus during interviews in a viewing booth titled *Video Traces*, placed near the *Tornado* exhibit. Through the use of video, visitors were able to more explicitly reflect upon and discuss what occurred during their experiences. Since they were able to come to some resolution of then puzzling phenomenon seen in the exhibit, visitors moved into higher levels of understanding as a result of explicit content connections. The authors also recommended that other ISIs use video booths with their interactive exhibits and ISIs should allow teachers opportunities to tape learning experiences when they bring their classes. They could then bring the tapes back to the classroom in order to continue the inquiry process about the phenomenon displayed by reviewing the tapes and allowing students to reflect on what occurred.

It would seem that both the reflective and social components described here would also apply to classroom teachers when they are involved in exhibit-related activities during professional development at ISIs. Of the estimated 2,500 Informal Science Institutions (ISIs) in the USA, 75 % serve schools, school districts, teachers, and students in some educational capacity (Center for Informal Learning and Schools [CILS], 2004), and many ISIs offer in-depth professional development serving over 27,500 K-12 classroom teachers. When participating in science focused professional development, 40 % of all elementary teachers do so at an ISI (Inverness Research Associates [IRA], 1996).

When considering the literature regarding ISI professional development and whether these programs are adequate for K-12 classroom teachers, it seemed important to address the qualifications of those involved in creating and implementing the PD programs first. In terms of in-house programs, wide ranges of qualification were reported but the emphasis was on the fact that PD staff consisted of certified teachers or scientists (Phillips, Finkelstein, & Wever-Fredichs, 2007). However, while many study participants claimed to have been certified teachers or had degrees in science and/or education, they would not necessarily be the ones responsible for actually conducting the programs (Astor-Jack, Balcerzak, & McCallie, 2006).

Some studies also described PD as a way to inform teachers of available ISI resources and promoting the institution itself (Chin, 2004; Melber & Cox-Peterson, 2005; Neathery, 1998) or how to create productive field trips (Chesebrough, 1994; Ferry, 1993, 1995; Olson, Cox-Peterson, & McComas, 2001). Granted, such programs are important since most teachers are not always aware of ISI resources available or how to properly prepare students for field trips (Anderson, Kisiel, & Storksdieck, 2006). However, many of the in-house programs discussed were very short, ranging from half a day (Melber, 2007) to 4 days (Neathery, 1998), which may be appropriate for a brief introduction to ISI resources but would not be appropriate if any teacher change was expected to occur. It was also not clear how exhibits were used during ISI PD for teachers. Therefore, the question guiding this study was as follows: *During ISI professional development, how does the use of exhibits affect elementary and middle school classroom science teachers' content-related social interactions?*

Methodology

This study addressed the question by looking at a course that was offered at and taught by educators at a large ISI in the Midwest, USA. These innovative courses were aligned with the state's education standards for science and designed according to the *National Science Education Standards* (National Research Council [NRC], 1996). The course addressed life science content and was offered to two different groups of teachers during the academic school year and a third group during the summer. The academic year courses met six times, approximately once a month from September through the beginning of June, and provided 42 contact hours overall. The last meeting consisted of participants reflecting upon their experiences of the course and giving presentations about implementing lessons in their classrooms based on course content. The summer courses covered the same content but took place over five sequential days for 35 h. Participants learned about the courses through word of mouth, by participating in other professional development held at the ISI, at education department open houses for teachers, on the ISI's website, or e-newsletter. Both the academic year and the summer course participants provided a sample of convenience for this study. The course was primarily taught by seven educators with a range of 2–5-year teaching experience at an ISI. A few were also classroom teachers prior to teaching at the ISI: Two were elementary school teachers, others had content backgrounds in social studies, environmental science, and reading, and there was a librarian as well.

The course complemented a permanent life science exhibition and primarily included interactive exhibits along with preserved and plastinated specimens. The topics for each of the meeting dates included: an introduction to the course; cells, tissues, and organs; body systems; DNA, genetics, and evolution; health and wellness; and forensics. In addition, another permanent exhibition was used during the course to address-related content, consisted of exhibits about cloning, genetic engineering, DNA, genetic counseling, and the human genome, and included a baby chick hatchery. Teachers discussed science content and practiced inquiry-based

classroom activities during this course, and the participant outcomes for this course aimed to achieve cognitive and social outcomes (in addition to outcomes addressing teacher attitudes and pedagogy). While this study focuses on the content outcomes, another paper addresses teachers' self-efficacy and attitudes during ISI PD (Holliday, Lederman, & Lederman, 2014). After participating in this course, it was hoped that teachers would achieve the following outcomes in terms of content learning:

- Describe how organs, tissues, and cells perform specific human body functions (cognitive).
- Differentiate how each of the body systems is designed to fulfill a specific function, works interdependently and is affected by your choices (cognitive).
- Explain that genetic material determines characteristics that can be altered by internal changes and external factors (cognitive).
- Demonstrate that to be socially, emotionally, mentally, and physically healthy you must make educated, positive choices (cognitive).
- Be able to facilitate exploration of health, wellness, and human body concepts at a level that is appropriate for their students (social).

Sample

Course participants were classroom teachers who spent 80–100 % of their time working directly with students 9 through 14 years old, with up to 30 years of teaching experience ($\bar{x} = 7.5$ years). All applied online to attend the course, and ISI staff evaluated the applications to decide who may participate based on need for content knowledge, need for science materials for their school (which was determined by the school's free-lunch status), and previous participation in the professional development program. Each course had approximately 30 teachers in each. Three courses were included in the study, with a total of 94 participating

Table 1 Course participants ($n = 94$)

	Summer 2010	Academic year 2010–2011		Total
	Group 1	Group 2	Group 3	
Total number of teachers	32	29	33	94
Public school (PS) teachers	16	17	18	51
Non-PS teachers	16	12	15	43
Suburban public school teachers	8	4	5	17
Parochial/private school teachers	5	10	6	21
Out-of-state teachers	1	–	–	1
Has previously participated in a course at the ISI	11	4	7	23
Primarily teaches science	15	16	10	41

teachers (see Table 1 for teacher demographics). In compliance with Institutional Review Board (IRB) protocol, all participants were asked to complete a consent form during the first meeting of each course.

Data Collection and Analysis

In this study, participants were videotaped and audiotaped while engaged in both courses and were made aware of this when signing the IRB approved consent form. In addition, teachers were asked to carry Livescribe audio-recording pens while they were engaged in the exhibit areas or with exhibit-related activities. The researcher used the same device when taking field notes and making non-participatory observations. This allowed for the written notes to be linked to the audio recorded at the same time. Three courses had six groups of two to three teachers in each, for a total of 18 groups overall, providing approximately 50 h of audio and 10 h of video recordings centered on teachers using the ISI's exhibits. Due to the difficulties of separating out subsets of teachers for the discussions, all teachers participating in the courses were included ($n = 94$).

Using *Transana*, an open-source software package, the video and audio were analyzed for teacher content-related social interactions and discussions. This software enabled the researcher to produce transcripts from digital video or audio data, with options to assign keywords, to identify segments of interest, and to organize the segments to facilitate investigating relationships that were present. In this study, the contexts of interest included interactions related to exhibit use during the PD. Further, the exhibit-related interactions took place during three sessions over the course of a summer and the academic school year, minor differences naturally occurred, and only common content and activities across the courses were analyzed.

Interaction Categories

While there was a great deal of data to consider, to best address research question, only those interactions that occurred while teachers were involved directly with an exhibit or an activity related to exhibit content were analyzed for this study. As a first step, conversations were categorized as non-exhibit or exhibit related. The focus then turned to developing categories within the exhibit-related discussions. Initially, discourse from all participants was reviewed at the same time and in random order. After multiple readings, statements that kept reoccurring were then entered into an Excel spreadsheet and grouped.

During the analysis, it became clear that PD staff used a variety of instructional strategies when asking teachers to interact with the exhibits and these strategies targeted content in an implicit or explicit manner. Therefore, categories were developed based on whether course content was addressed an implicit or explicit manner when using exhibits (see Table 2 for examples).

When teachers were given an opportunity to investigate the life science exhibition on their own and without direction, this was considered to be "free exploration." If PD staff gave some open-ended, general, questions about the

Table 2 Examples of implicit and explicit use of exhibits

Implicit exhibit use	Explicit exhibit use
Free exploration	Worksheets
Guiding questions	Demonstrations
Guided tours with facilitators	Guided tours with PD educators
Guided tours with exhibit designers	Related activity

overall exhibition, this was identified as "guiding questions." During the PD, teachers also went on a number of guided tours given by various ISI staff. These included facilitators (volunteers or docents), exhibit designers, and the educators that lead the PD. All had various approaches and objectives for the tour but the PD educators were more likely to address content in an explicit manner. When using worksheets, the questions were directly related to the content presented during the PD and/or particular exhibits found in the larger life science exhibition. Demonstrations were often short-term experiences presented by facilitators within the exhibition and related to the content found there. Finally, there were also "related activities" that were often lead by PD staff and were conducted within the exhibit areas. While the content may have been explicitly addressed, this was not always true for the exhibits themselves.

Once the transcripts were produced and areas of interest became evident through the subsequent analysis, segments of interaction from each context (implicit versus explicit content connections) were compared and frequencies were produced. As a result of this inductive analysis, the initial categories that emerged were as follows: *Personal* (but related to the content), *Content based*, *Pedagogical*, or *Unrelated* (to content and exhibit). During the analysis, teachers' coded statements were also counted and graphed in order to compare (and visualize) the types of conversations that occurred during each of the above exhibit experiences. Through this process, three additional categories emerged: *Reaction* (with teacher stating "Wow!" or "Look at that!" and little else), *Prior Knowledge* (when the teacher would draw upon prior knowledge and connect to the exhibit content), and *Unclear*.

Results

Throughout the academic and summer content courses, teachers were engaged in a number of exhibit-based experiences that included both explicit and implicit content connections. The discussion will now focus on comparing teachers' exhibit-related conversations that occurred while participating in traditional guided tours (with implicit content connections) that were used to introduce teachers to the exhibition, while engaged in self-guided exploration with three guiding questions (also with implicit connections), and while using a worksheet (with explicit connections). Each of the formats will be addressed by describing three exhibits found in the life science exhibition: *Artificial Skin*, *Blood Composition*, and *Fetal Development*. Each instructional format and the related contexts will be discussed and compared

for each of the exhibit areas. These specific exhibits were chosen since they addressed a number of content objectives for the PD.

Guided Tour

The observed guided tour occurred in the exhibition at the beginning of the summer course. It was lead by one of the exhibit designers, and he explained all of the exhibition themes and particular exhibits within each area, essentially providing an introduction to the overall exhibition.

The guide began by discussing the "high-tech human" exhibit area of the exhibition, particularly pointing out a robotic prosthetic arm on display and inviting one of the teachers to attempt to move the robotic arm by slipping her wrist into a control. She attempted to move her wrist and fingers in an effort to move the robotic arm but was not successful. The guide continued to talk to the group but did little to assist her while she was interacting with the exhibit. Found in the same area, the *Artificial Skin* exhibit was not discussed during the tour.

Teachers were then taken to an area with a 13-foot-tall, 3-dimensional, digital model of a heart. Here, visitors can place their hands on receptors that pick up his or her heart rate. The digitized heart replicates the individual's pulse or can also be made to simulate heart attacks or other health-related issues. The exhibit designer explained that this exhibit replaced an older heart exhibit that allowed visitors to walk through the chambers. He also invited the tour group to wander around the area to investigate the interactive exhibits; however, teachers did not do so. Instead, one teacher was chosen to demonstrate how the heart exhibit worked and was assisted by an exhibit facilitator. While doing this, the facilitator explained that a normal heart rate would be between 70 and 100 beats per minute. He also explained that the red areas on the heart represented oxygenated blood and the blue areas represented de-oxygenated blood, further perpetuating a common misconception.

Nearby there was an interactive exhibit describing the composition of blood showing a realistic animation of the interior of a blood vessel on a touch table, and visitors can touch an image of a red blood cell, macrophage (a type of white blood cell), or platelet, among other things, and drag the object to animated magnifying glasses in order to see it up close and learn more about the structure. However, teachers did not see or interact with the exhibit at this time.

After this interaction, the teachers followed the exhibit designer as he continued with the tour by bring them to the *Fetal Development* exhibit. He started by explaining that this exhibit was older and had been updated. Dating from 1939, the exhibit contains 24 preserved human embryos and foetuses ranging from 28 days to 38 weeks old. This information is provided on text panels with minimal additions. Also, there was a viewing area with a wrap around screen showing a 6-min video that depicts the development of a human foetus from the moment of conception. Due to the age of the exhibit, many of the teachers indicated that they were familiar with it and little time was spent here before the guide wrapped up the tour.

However, there is an important item to note: Prior to the tour, teachers were asked to wear headphones, and the guide spoke into a wireless microphone. While this enabled everyone to hear what was being said in a noisy environment, this did

not encourage discussions among the teachers or between the guide and his audience. For the most part, teachers were silent throughout the tour. At the end, the guide asked the group for questions but was not able to address them since time was running short. When returning to the classroom space, the experience was not debriefed and teachers were asked to fill out evaluations for that session since it was the end of the day.

Self-Guided Exploration

During the beginning of the academic year course and before being introduced to much of the content, teachers guided themselves through the same exhibition and answered three focus questions:

1. Write down something that you didn't know before;
2. write down one unanswered question that came about as a result of being in that exhibit; and
3. answer one of the questions in a provided exhibit guidebook.

The following pair of teachers visited the "high-tech human" exhibit area on their own, and this time around, they noticed the *Artificial Skin* exhibit but did not elaborate beyond reacting to the exhibit:

Teacher 1: Huh … fake skin …
Teacher 2: Wow!
T1: Oh, look at that …
T2: Yeah …
T1: Dermis is your skin … real skin … artificial skin…huh!

Also during this time, a number of the teacher groups came upon *Blood Composition* exhibit (near the giant heart) and briefly interacted with it. However, one group did not seem to realize how to interact with the touch screen interface. Again, they simply reacted to the visuals and then moved on to another exhibit. For instance,

Teacher 1: Oh no!… Red blood cells … plaque … red blood cell … [*slowly pronouncing*] macro … phage? Macrophage destroy harmful bacteria swallowing them whole …
Teacher 2: Wow
T1: There's bacteria … Oh, my God! Look what it's doing!

As they were freely exploring the *Fetal Development* exhibit, many teachers went to this exhibit area since they had remembered seeing it before and/or the specimens seemed to be fascinating to them. The following group started to talk about the beginnings of cell division:

Teacher 1: Oh look how tiny!
Teacher 2: 1 month
T1: Oh

T2: And that's already at 28 days …

Many teachers also spoke about whether the embryos and foetuses were real, how the institution acquired them if they were, in fact, real, and how they were preserved.

Worksheet

Later during the academic year course, teachers were given worksheets to complete while revisiting the exhibition. Prior to this, in the classroom space, teachers were introduced to an activity that equated the parts of an animal cell to parts of a factory. This was followed by a PowerPoint presentation that reinforced the content. After completing the activity, other activities about cell specialization, the variety of cell types (blood, neural, muscle, etc.), and the regenerative qualities of cells were introduced to the group.

One group of teachers found it difficult to address the following question on the worksheet, "You're a scientist, too. What would you use to create artificial skin?" This was especially true when they considered how their own fifth-grade students could answer such a question while at the *Artificial Skin* exhibit. They began to think of ways to restructure the question to make it more appropriate for their students.

Teacher 1: I don't know … um … "What would you use to create artificial skin?" is the question …
Teacher 2: A hard question
T1: Not cow tendon and silicone rubber. Naturally, that would not be my first guess… I have to say
T2: Our kids would need to know what cow tendon is
T1: Um … that's a good point
T2: They wouldn't know what tendon is
T1: I'm not sure they would recognize silicone-rubber.

[Later in the discussion}

T2: It might be better if we gave them [the students] some ideas … to build off of. Instead of just asking such an open-ended question?
T1: Yeah, I know our kids … yeah

Back in the classroom, staff debriefed the questions by asking the teachers for their answers to several of the worksheet questions. The discussion also included teachers sharing their ideas about ways to use the worksheet with their students as a management technique during field trips. The staff member also briefly mentioned that it would be more meaningful for students if they had some content knowledge before coming to the ISI and suggested some post-visit activities to reinforce learning that occurred during the field trip when they returned to school.

Through this process, teachers' conversations became more detailed when working on their worksheets. The following question asked teachers to "Find the twin female foetuses. What is the difference between the fertilization process of

identical twins and fraternal twins?" and the answer to this question could be found in the text label in the *Fetal Development* exhibit. This group's conversation also provides a good example of personal and content-related interactions overlapping:

Teacher 1: With the ah … identical twins it was a single fertilized egg … that split but if they're uh … separate fertilized egg
Teacher 2: They're fraternal
T1: Then they become fraternal
T2: Like me and my sister
T1: Right … so you fraternal or … ?
T2: We're fraternal
T1: Fraternal?
T2: Now with the single egg … you have exactly the same genes right and then … they … carbon copies of one another
T1: Yeah … so they duplicated …

Another question asked teachers to "Describe or sketch how a foetus develops from one single cell in the space below." While they were in the exhibit area, this question attempts to have teachers connect to content addressed earlier that morning in the classroom. In the earlier activities, the larger group was divided into two smaller groups. One group created a model of a fertilized cell dividing using modeling clay, and the other engaged in activities about mitosis. Once the activity was completed, the groups switched.

While creating their cell models, teachers were instructed to take a ping-pong-ball-sized piece of clay (which represented the zygote), divide it in half (representing two cells), then divide those two in half (representing four cells), and so on until they formed a sphere with 16 cells (a morula). Teachers proceed by making a hollow bowl in another color (the placenta) and place the morula in it, creating the blastula. The lesson continued to include a discussion about embryonic stem cells and, once cells have differentiated, adult stem cells that are cell specific. While the staff member leading the lesson utilized PowerPoint slides, a document viewer to show an example of the model, and asked whether anyone had questions, many teachers still expressed confusion during the activity.

While working on the worksheet after the stem cell activity, teachers tried to help each other to understand the content; however, the exhibit itself did not provide much additional information that would help to answer the question. In the following discussion, clarity came with teachers were trying to make sense of the question:

Teacher 1: Okay, so we have one cell and then it doubles every 12 h… remember we learned that in class?
Teacher 2: Right, right …
T1: So, then it's one cell … and then it becomes two cells … and then 24 h … it become four cells and within 36 h … because she [the ISI staff member] said every 12 h … and then it becomes 8 … and then with 48 h … we got 16
T2: It doubles every six?

T1: Mm mm [shaking her head no] … 4 and 4 … is 8 …
T2: Oh, so it doubles, okay
T1: Hm hm [indicating yes] …
T2: 8, 8, 8
T1: So, actually … in two days it becomes 16 … that's why she said that … remember how I kept saying how come it's … 16?
T2: Right
T1: Why did it have to be 16? 'Cause she [the staff member] was doing a 2 day cycle!

Implicit and Explicit Connections to Content

While there was little discourse during the guided tour due to the headphones, another implicit connection to the content (the guiding questions) was compared to an explicit connection (the worksheet). The focus will be on the following three categories: *Content Based*, *Personal*, and *Reaction*. The majority of teachers had these types of conversations while far fewer discussed other issues such as pedagogy.

Addressing Fig. 1, only two groups of teachers went to visit the *Artificial Skin* exhibit during the free exploration with guiding questions and had minimal discussion during that time. Of those discussions, 43 % were *Content Based*, 19 % were *Personal,* and 38 % were *Reaction* statements. Meanwhile, more groups visited the exhibit when using the worksheet and the *Reaction* statements decreased to 4 % and the number of *Content-Based* statements increased to 95 %. There were no personal statements when using the worksheet during this portion of the PD. One group in particular discussed pedagogical concerns with the worksheet as well as the content. Initially, during the free exploration, the number of reaction statements may be due the novelty of the exhibit. However, many teachers did not go to the exhibit of their own accord even though it was part of the content presented that day. When

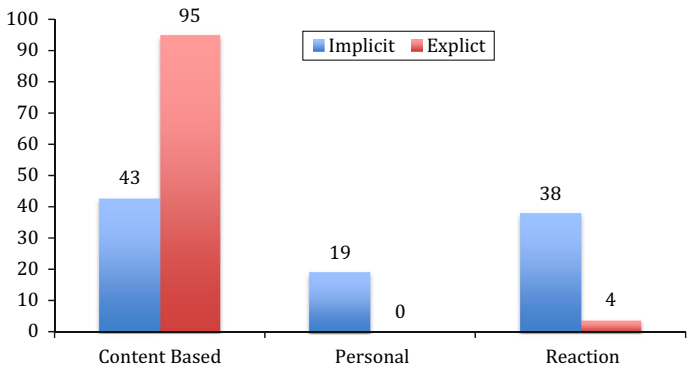

Fig. 1 Artificial skin: comparison of conversations using implicit and explicit instructional strategies

directed to go there during the worksheet assignment, the number of reaction statements were greatly reduced to one group (only 3 % of Group 2's statements were coded as *Reaction*). The overall number of statements also increased when teachers were using the worksheets (from 16 to 87).

Regarding the *Blood Composition* exhibit, the conversations were similar to that of the *Artificial Skin* interactions. However, this time, the free exploration experience (see Fig. 2) elicited more *Content-Based* statements (68 %). There were no *Personal* statements and the *Reaction* statements were about the same. At the same time, the whole experience was very brief, included few statements, and the depth of conversation was shallow. Meanwhile, when using the explicit strategy (the worksheet), teachers still had *Reaction* statements but far fewer of them (15 %) and slightly more *Content-Based* statements (85 %). Group 1 also discussed pedagogical issues (20 % of their statements) when working on the worksheet questions.

Judging by the large number of statements overall (1,136 total), the *Fetal Development* exhibit seemed to be of high interest to teachers and, as indicated in Fig. 3, very personal. Although the discussions lasted only 4–7 min during the free exploration, all groups made some personal connections to what was displayed and comprised 56 % of the conversations. Very little was *Content Based* (18 %). Again, a bit of the discussion was purely reacting to what was on display, with those statements being about 26 % of the conversations.

The worksheet provided some direction for teachers and the *Content-Based* conversations increased for all groups (72 %) while *Reaction* and *Personal* statements greatly decreased to 21 and 7 %, respectively. The overall time spent in this exhibit area also increased to 20 min. However, as an aside, there was a notable spike in *Unrelated* conversations for one of the eight groups. This is partly due to spending most of their time in another exhibition area and 40 % of Group 2's conversation was coded as such.

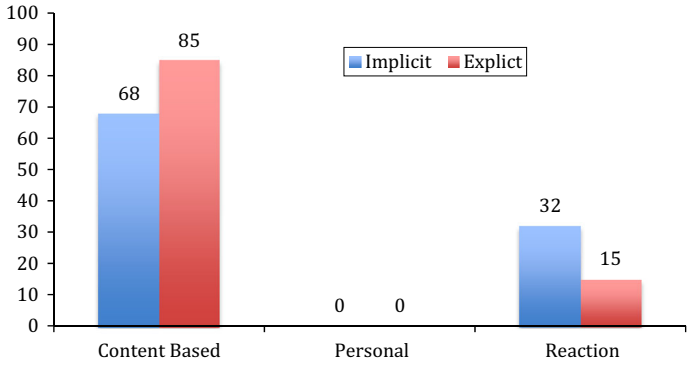

Fig. 2 Blood composition: comparison of conversations using implicit and explicit instructional strategies

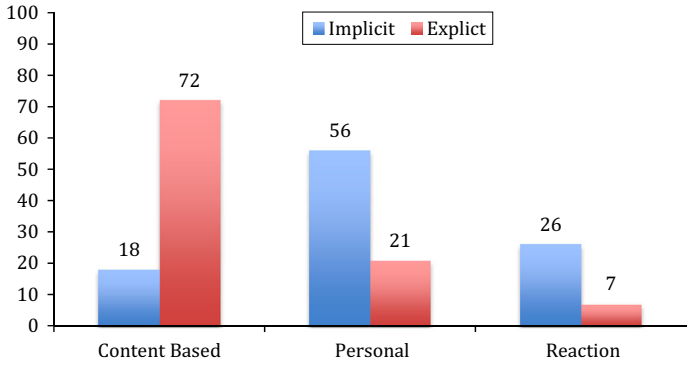

Fig. 3 Fetal development: comparison of conversations using implicit and explicit instructional strategies

Discussion and Implications

Gee and Green (1998) wrote that "people do not talk (or write) for talk's sake… Rather, they talk (and write) for a purpose" (p. 136). Here, it seemed that teachers' talk always had a purpose but it is argued that it did not always have a direction or connection to the desired content or exhibit. Exhibit tours, especially when led by exhibit guides and facilitators, also did not contribute to deeper understanding of content due to implicit content connections during the tour and little guided reflection when back in the ISI's classroom.

In their study, Cox-Peterson, Marsh, Kisiel, and Melber (2003) stated that the observed guided tours made few connections to existing science education documents. The content was presented in a didactic, narrative style and the structure of the tours was not aligned with the recommendations of the *National Science Education Standards* (NRC, 1996); the American Association for the Advancement of Science (AAAS, 1993, 1994); or to findings reported in informal learning literature (e.g., Falk & Dierking, 2000; Hein, 1998, 1999). Although studies have emphasized that this is not the case (e.g., Tran, 2007) and that informal educators were effective in teaching, the exhibit designer and facilitator led tours observed in the current study confirm these findings. However, in the study presented here, when the ISI educator led the tour, more explicit connections to the content were made during this time.

Tran and King (2007) have suggested a central knowledge framework that should be required of ISI educators and includes the following:

- *Theories of learning*
  - *Constructivism*—acknowledging that ISI educators are intermediaries between the museum's construction of knowledge and visitors' ways of knowing.

  - *Socio-cultural*—learning occurs as a result of interacting with people, objects, and events in the environment (e.g., Vygotsky, 1986).

- *Talk*
  - The social context of ISIs favour the spoken word and ISI educators seem to rely on talk-based interactions (Cox-Peterson et al., 2003; Tal & Morag, 2007; Tran, 2007).
  - Currently, there is little evidence that ISI educators are able to facilitate deep or meaningful discussions with visitors (King, 2006; Pedretti, 2004).

Tran and King (2007) go on to state that Shulman's (1986) categories of knowledge (content knowledge, pedagogical content knowledge, and curricular knowledge) should be adapted for ISI educators and their underlying professional practice. While they use the word "museum," it will be stated here as "ISI," becoming *ISI content knowledge, ISI contextual knowledge,* and *ISI pedagogical knowledge*. It was admitted, and the research has shown, that more work needs to be done in order to understand the precise nature of each category of knowledge and how they would be put into practice.

When freely exploring the ISI, teachers often purely reacted to the display itself or the novelty of it. Again, as was shown with Stevens and Hall's study (1997), moving beyond a cause and effect reaction and toward an understanding of concepts requires reflection and guidance on the part of PD staff. The guiding questions or worksheets seemed to assist in directing conversations to be more content based, but teachers did not always stay on task when asked to use guiding questions. In terms of the worksheets, exhibits were not always necessary and the questions could be confusing. Clear objectives, and an understanding of what teachers should come away with, would also assist with the development of materials to be used with exhibits. Kisiel (2003) described concept and survey worksheets when teachers used them with their students on field trips. A survey worksheet would often require students to use many exhibits in a shallow manner (fill in the blanks, find the object, etc.) while concept worksheets were used to develop students' conceptual understandings and addressed overarching themes (as part of problem-based learning, for instance). It would seem that it would be useful for teachers to have similar experiences with a variety of ISI-based instructional strategies while they are engaged in ISI PD. Unfortunately, in this case, exhibits were not used in novel ways and were not incorporated into inquiry-based activities in the observed courses.

When focusing the two factors within the sociocultural context of CML: *within-group sociocultural mediation* and *facilitated mediation by others*, PD staff and educators also did not use exhibits in a way that fully took into account both of these elements. On a number of occasions, the teachers primarily toured the exhibits, usually with a guide and microphone broadcasting to the headphones worn by all participants. As a result, there was little or no interaction among the teachers during the visits since they simply followed the tour guide and listened. However, when explicit connections were made between exhibits, content, and activities, participants were more involved in in-depth, content-related and pedagogical

conversations while engaged in the course as a result. Whether exhibits were related to each other or not did not seem to be as important as the facilitated mediation by PD education staff.

It has been shown that classroom teachers tend to use formal teaching practices when on ISI field trips (Griffin & Symington, 1997), and the same has been shown for ISI educators. This is may be due to prior experiences as classroom teachers or being students themselves. Nonetheless, and for whatever reason, ISI educators tended to utilize formal teaching practices in informal settings (Cox-Peterson et al., 2003; Tran, 2007). More recently, Kisiel, Magdziarz, Ross, and Cox-Petersen (2011) described professional development for ISI educators and formal instructional strategies were used here as well. This tendency, along with the practice of not allowing enough time for reflection, greatly influences the depth and breadth of learning and produces shallow informal learning experiences (e.g., Holliday et al., 2014).

The ISI educators in this study did not consciously consider discourse as a part of the learning process and did not intentionally include opportunities for explicit or implicit content connections when using exhibits. Also, when exhibits were used during the courses, they were not always clearly tied to the instruction occurring in the course or would obfuscate content that had been covered. An assumption was clear on the part of PD educators that, when used, an exhibit would be able to convey the desired science content on its own. However, judging by their conversations, teachers made personal and pedagogical connections to content but did not make content-based connections unless explicit connections were made through instruction.

While talking to each other when engaged with the exhibits, teachers not only attempted to make sense of the science content for themselves but for their students as well. They were constantly trying to figure out how to best present the information to students and how to use the exhibit texts or associated guidebooks/worksheets for their classroom visits. As a result, teachers' content-related social interactions benefited from explicit connections to exhibit content and opportunities for reflection. Activities and instructional strategies that were linked to the content occurring before and/or after the exhibit visits extended these interactions and contributed to further learning. In addition, when designing future ISI PD for teachers, explicit connections to science content and assessments linked to the instructional objectives of the course should be carefully considered (Holliday et al., 2014).

The discourse teachers engaged in seemed to play an important role in developing their understanding of science content. When provided with adequate time and opportunities for reflection in exhibit areas, teachers were able to reflect upon and "digest" the content presented earlier in the day. Comparisons were also made when looking at three exhibit areas and three instructional strategies that used exhibits during the course. Conversations became more content based as teachers progressed through the courses and had more experiences with explicit connections that were presented through instruction.

While all teachers may not receive such in-depth ISI PD that addresses science content found in exhibits in an implicit or explicit manner, the findings described

here should be generalizable to all developers of ISI professional development for elementary and middle school science teachers. In particular, this study will help ISI PD staff understand how exhibits play a role in developing elementary and middle school science teachers' science content knowledge and how these exhibits, along with related activities, impact their content-related social interactions.

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