Lessons Learned in Summer Camp: A Case Study of the Learning Paths of Three Campers

Lauren Madden
The College of New Jersey

John C. Bedward
North Carolina State University

Eric N. Wiebe
North Carolina State University

Claudia R. Benitez-Nelson
University of South Carolina

Abstract

Science camps provide opportunities to expose students to topics of interest to students that are not typically covered in the classroom, such as marine science. This multi-case study examines learning paths for three campers enrolled in a marine science camp for elementary age children. Interviews, knowledge inventories, and science notebook analyses were triangulated and resulted in narrative learning path descriptions. We found: 1) each camper followed a unique learning path throughout camp; 2) campers' learning was socially constructed; and 3) the campers each preferred concrete representations of phenomena over abstraction. These findings suggest Ocean Explorers is an effective mechanism for not only allowing elementary-aged students' to pursue a science topic of personal, but also for increasing their content knowledge in marine science using concrete representation.

Correspondence concerning this article should be addressed to: Lauren Madden, madden@tcnj.edu

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Summer camps provide students with educational experiences outside the traditional classroom environment. Most children (ages 5-18) in the United States of America (USA) attend mandatory schooling from August through June, leaving 8-12 weeks during the summer free from formal education. As a result, more than 11 million children across the USA attend camps each summer (ACA, 2010). These camps can vary in duration from one to ten weeks, and include both residential and day camps[1]. Summer camps offer opportunities to explore topics of personal interest and interact with peers and educators outside the typical school setting, where

[1] In day camps, children return home each day when camp activities conclude.

learning outcomes and achievement testing are mandated by state and federal laws. Science camps, in particular, provide opportunities to cover science topics not addressed in traditional school science curricula, such marine science or robotics. At the elementary school[2] level in the USA, science instruction is often limited, meaning that for many children, experiences from outside the more traditional formal educational settings account for much of the science learning experiences (NRC, 2009). The purpose of the following qualitative case study is to describe the learning and experiences of three elementary school- aged campers enrolled in a one-week marine science summer camp. The students' learning paths were examined and the effectiveness of marine science camps in increasing marine science content knowledge was explored.

K-12 Marine Science and Informal Education

The world's oceans cover more than two thirds of Earth's surface, representing its largest ecosystem. The oceans serve as a reservoir for many natural resources providing humans with minerals, medicines, food, power, and transportation. Despite their great importance, few of the National Science Education Standards (NSES) at the elementary level directly address content related to marine systems (National Research Council [NRC], 1996)[3]. As a result, in 2004, the Ocean Literacy Campaign created a standardized framework for marine science learning (Cava, Schoedinger, Stang, & Tuttenham, 2005). In the framework, *Ocean Literacy: The Essential Principals of Ocean Sciences*, the National Marine Educators Association (NMEA) outlined the key components of ocean literacy and linked them to the NSES (NMEA, 2006), in an effort to aid educators and curriculum developers in creating NSES-aligned curricula with a marine science focus. Though some efforts to create ocean-oriented curricula have been underway (e.g. *Island Explorer's,* USC Seagrant, n.d.), these materials are rarely incorporated in the widely used science kits or textbook-based elementary science curricula. Given the lack of attention paid to the oceans by most formal (i.e., school) education curricula, informal science provides a unique opportunity to expose children to marine science content knowledge.

Research in informal science learning is a relatively new, but growing field, and has great opportunity to expand our understanding of how learners come to understand science (NRC, 2009; Rahm, 2014). Studies have shown that students who experience informal science learning have an increased interest in science (Fenichel & Schweingruber, 2010). For example, Gibson and Chase (2002) conducted a longitudinal study of middle school students enrolled in an inquiry-based summer science camp. These students' interest in future science careers were higher than a comparison group, and continued to grow over time. Ramey-Gassert (1997) found that informal experiences are more authentic, and this authenticity creates salience that increases student interest. Authentic scientific experiences have also been shown to improve students' science process skills (Fenichel & Schweingruber, 2010; Rath & Brown, 1996). Furthermore, informal science experiences are linked to increases in confidence in science, especially for females when given opportunities to explore science in informal settings (Fenichel & Schweingruber, 2010; St. Pierre & Christian, 2002).

[2] In the USA, elementary schools serve children ages 5-12.

[3] It should be noted that the NSES have been replaced by the Next Generation Science Standards (NRC, 2013). These also lack direct connections to marine science at the elementary level.

Though researchers largely agree that informal science can affect students' beliefs and interest in science, relatively few studies address changes in students' science *content knowledge* after participation in informal science. Farmer, Knapp, and Benton (2007) conducted an interview study of elementary school students a year after a hands-on environmental science field trip, and found that the students retained content covered during the field trip as assessed by the explanation of key information they learned during the experience in interviews that took place one year after the trip occurred. In a report evaluating the effectiveness of an informal marine science program at the National Aquarium of Baltimore, the Center for Public Program Evaluation (2009) found that, in addition to changing students' beliefs about the importance of conserving marine ecosystems, both fourth and fifth grade students demonstrated increases in knowledge about marine science content (such as flow of energy in food webs and coastal landforms). Taken together, these findings support the notion that authentic experiences presented through informal science learning have great potential to increase content knowledge along with interest (Ramey-Gassert 1997). Yet, a more recent study (Holliday & Lederman, 2014) suggest that learners in informal environments often times focus more on the process of science and the "fun factor" of informal science learning experiences rather than content studies. Thus, it is essential to keep an eye toward content learning when developing and assessing informal science learning experiences.

The National Association for Research in Science Teaching (NARST) issued a position statement on informal science education in 2003 (Dierking, Faulk, Rennie, Anderson, and Ellenbogen, 2003). This statement asserted that acquisition of informal science knowledge relies on peer-to-peer and instructor-to-peer interactions, thus is socially constructed. Likewise, Rennie, Feher, Dierking, and Falk (2003) offered that informal science learning is both a process and a product, thus it is essential to study both of these pieces, including the social mediating factors (e.g. conversation, learning networks, and cultural dimensions), to truly understand how informal learning takes place.

Social Constructivism & Science Learning

Social constructivism is the central notion that knowledge is socially constructed among people. Driver, Asoko, Leach, Mortimer, and Scott (1994) suggested that it is the *community* of science that constructs meaning and develops interpretations of phenomena. In other words, Driver and colleagues suggested that typical science instruction replaces one set of theories with another (naïve ideas with scientifically accepted theories) rather than fostering conscious transformations in students' scientific understandings. This social discourse about scientific ideas may be a critical influence on conceptual change. Similarly, Foreman and Cazden (1985) explained the cognitive value of peer interaction and proposed that peer interactions form an intermediate step between children's inner speech and external interactions such as those that occur between children and adults. These interactions allow the children (and their teachers) to interchange roles in a continuum between novice and expert. Though roles may be traded, expertise within groups is distributed. Brown, Ash, Rutherford, Nakagawa, Gordon, and Campione (1993) suggested that each member of a group has ownership of unique pieces of knowledge, and with this ownership comes mutual respect and personal responsibility for learning. Rogoff (2008) echoed this sentiment in describing participatory appropriation as the way in which individuals transform their understanding of activities through their own participation.

The teacher's content expertise can define his or her role in a group, while understanding of students' knowledge can allow the teacher to structure pairings and groups and allow individuals to develop and grow as they participate in the instructional activities and allow. students to work within their zones of proximal development (ZPD) (Brown et al, 1993; Foreman & Cazden, 1985; Rogoff, 2008). Vygotsky (1978) defined the ZPD as:

> the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (p. 83)

Foreman and Cazden (1985) later described Vygotsky's definition of the ZPD as the space between an individual's achievement ability on his/her own and what s/he could achieve with the help of a more capable other. Informal learning experiences, such as science camps provide instructors with the freedom to structure groups and activities in a manner that capitalizes upon children's different levels of expertise, and allow individual campers to work within his or her own ZPD. Such group interactions further facilitate scientific discourse and the construction of socially derived scientific meaning.

Methodology

Study Context

Ocean Explorers Science Camp was a one-week half-day science camp held at a church in an urban/suburban area in the Southeastern USA. This area is approximately 150 miles from the Atlantic Ocean. The camp was advertised to parents of children ages 5-12. However, the children who enrolled were all between the ages of 6 and 8. The camp was funded through parent-paid tuition. The camp's curriculum was informal and guided by an abbreviated version of the *Island Explorers* marine science curriculum (USC Seagrant, n.d.). *Island Explorers* contains 22 hour-long hands-on inquiry-based lessons organized into four thematic units addressing: geological features of the earth, biodiversity, interactions between marine organisms, and human impact on the ocean. Introducing students to marine science through the modified *Island Explorers* curricula has the potential to benefit students as these concepts relate to other ideas typically covered in elementary science including soils, landforms, and ecosystems. Due to time constraints, and the young age of the campers enrolled in our camp, specific activities from the *Island Explorers* were selected and modified to provide children with an opportunity to explore multiple components of marine science. Each activity used in our camp directly addressed one or more of the National Standards for Ocean Literacy (Cava et al., 2005). Modeling was also a key focus of the camp's activities. To interact with phenomena outside the human scale (i.e. larger and smaller than what the students could experience within the constraints of the classroom), the students watched videos of floating plankton, and of 3-D maps of seafloor features. Students then created conceptual representations (models) of these phenomena using everyday objects (for plankton), and clay (for seafloor features). The students also used toys and candy to represent marine resources such as food, pharmaceuticals, and oil, in an activity in which they role-played trading among countries for these resources. Finally, students were exposed to fish specimens, and compared their observations with teacher-provided diagrams. The students identified key features of the organisms using these diagrams, and created their own models based on their synthesis of observational data and information on the diagram.

The camp followed the general structure of the schedule pictured in Table 1, but modifications were made based on student needs and requests.

Table 1

Initial Ocean Explorers Camp Schedule

Day	Activities
DAY 1: GEOLOGICAL PERSPECTIVES	Shoebox Seafloor models Sand/Soil comparisons
DAY 2: PROPERTIES OF WATER	Density of salt and freshwater Models of plankton
DAY 3: ICHTHYOLOGY	External fish explorations Internal fish explorations
DAY 4: FOOD CHAINS AND FOOD WEBS	Sampling using quadrats Food webs in the ocean
DAY 5: HUMANS AND THE OCEANS	Sharing of Ocean Resources Toxins in an ecosystem

The modifications included shortening the Day 4 activities and adding: 1) a student-initiated experiment about density; 2) a reflective learning task; and 3) a shark-fact scavenger hunt. We incorporated these modifications based on our social constructivist beliefs that students are active participants and learners whose individual contributions are beneficial to the group at large. The students at the camp kept science notebooks documenting their experiences throughout all of the activities offered at Ocean Explorers camp. These notebooks were purposefully unstructured to allow students to represent their thoughts as they wished.

Research Questions

This study is guided by the following research questions:

1. In what ways can a one-week half-day science camp enhance three campers' knowledge of marine science content?
2. What are the learning paths of these children?

We described learning paths, derived from the definition for learning trajectories proposed by Simon (1995), as the path between the student's initial conceptions and the learning goals. Learning goals are defined for each of the camp activities as described in the *Island Explorers* Curriculum and the *Principals for Ocean Literacy*.

Participant Demographics

Five children attended the camp, and ranged in grade-level, from rising second to rising fourth graders (ages 6-8). Four campers were male and the fifth was female. Three children were white; two were multiracial. Two campers received half scholarships to attend camp. Four campers' parents provided consent for them to participate in this study (which received approval of the Institutional Review Board [IRB] at the university at which the authors were based); three campers participated in all parts of the study: David, Jason, and Rose (pseudonyms). The fourth camper declined to participate in a focus group interview portion of the study, and thus is excluded from this report. All three of the children who participated in the study were white; two were male and one was female. These three campers serve as the cases for this study.

All three of the campers in this study attended the same school in which students participated in less than two hours of science instruction each week. The average class size in this school is about 20 students. The school's science curriculum was driven by the NSES and the state science standards (based on the NSES). Prior to camp, David and Rose completed first grade, during which time the students were exposed to content including the basic needs of plants and animals, and how they are supported by environmental factors; the existence of a wide variety of organisms on earth; basic properties of solids and liquids; basic properties of earth materials, and how these vary by location (e.g. different soil types in different environments); and describing forces (push or pull). Jason completed second grade just before camp and was exposed to the above content as well as additional content including: life cycles of animals; changes in weather and climate; and changes in matter (e.g. chemical and physical reactions). All three children were able to read and write words phonetically, but the exact reading level for each child was not established prior to the study.

Study Design

A qualitative multiple case study design (Stake, 1995; Yin, 2009) was employed to describe the three campers. Case studies are used to study a particular phenomenon bound by parameters, such as time and activity (Creswell, 2003; Stake, 1995). In the context of Ocean Explorers camp, the cases are bound by the experiences of each of the three campers, while the issues are the mediating activities in which the campers participated and interactions between the campers. While the sample size for this study is small (n = 3), these children represented more than half the campers and their experiences can be used to describe differences in how each child learned throughout the camp. Given the small size, we are limited in our ability generalize our results to those of elementary aged students at large.

Triangulation of investigators and data sources were used to develop and validate these cases (Creswell, 2003). The data sources used to describe the cases of the three campers were: knowledge inventories, document analysis (photographs of campers' notebook entries), and one face-to-face focus group interview. Notes from the teaching journal of the camp director (first author) were used to supplement these data sources. After triangulation, a grounded thematic analysis of data (Riesmann, 2008) was used to construct narratives of each case.

Knowledge inventories. Fenichel & Schweingruber (2010) cautioned that assessment in informal science settings should be nonjudgmental and flexible; in that they can measure the learning of a wide range of participants. Thus, we decided that knowledge inventories about marine science before and after instruction would be the most effective tools for assessing the growth of the learners at this camp. Knowledge inventories were given to children as the first and last activities of the week-long camp. Campers responded to the following prompt:

Take 10 minutes to list all the facts you can think of about the ocean.
This is not a test, and there are no right or wrong answers.

Each camper's response to the knowledge inventory was transcribed and stored. The knowledge inventory prompt was purposefully designed to allow students to document their thoughts regardless of their initial (or final) level of content knowledge about marine science.

Notebook entry analysis. Each entry of each camper's notebook was photographed at the end of camp. These photographs were used to provide evidence of students' changing understandings about marine science throughout camp. Investigators used discussions with campers during the camp experience and focus group interviews to guide a grounded thematic interpretation of students' notebook entries (Reissman, 2008).

Focus group interview. Mantzicopoulos, Patrick, and Samarapungavan (2008) suggest that student interviews are particularly useful for allowing young students to describe their beliefs about science. On Day 4, the three campers stayed after camp for a 45-minute focus group interview with two moderators (first and second authors) using a semi-structured protocol to describe their notebook entries. We elected to use a focus group approach so that the campers could benefit from one another's knowledge and expertise when providing their responses. During the interview, campers were asked to select and describe their best notebook entries along with the entries that were most difficult for them to complete. They then described the activities in which they created the entry and what they learned during that activity. These particular entries (best and most difficult) were used as interview prompts as they likely had some salience for students, allowing them to provide the richest descriptions of their marine science content knowledge. After the interviews the first moderator synthesized notes from each of the three students' contributions to the discussion and sent the synthesis to the second moderator to ensure investigator triangulation.

One useful way to understand how the participants, as members of the Ocean Explorers Camp community alongside instructors, grew and changed over the course of the camp is through using a model based in Activity Theory (Engestrom, 1987). According to Activity Theory, subjects' (in our case campers') outcomes (in our case learning paths) are shaped by their interactions with each other and their instructors, tools (in our case curricula), and the group and societal norms, as can be seen in the Activity Theory Triangle depicted in Figure 1 below. In this diagram, norms are the "rules," which are somewhat different in summer camps than they are in traditional K-12 school settings. Each individual camper's unique learning path is shaped by each of these factors in a different way, and thus can be pictured as "skewed" triangles in the direction of the more dominant factors.

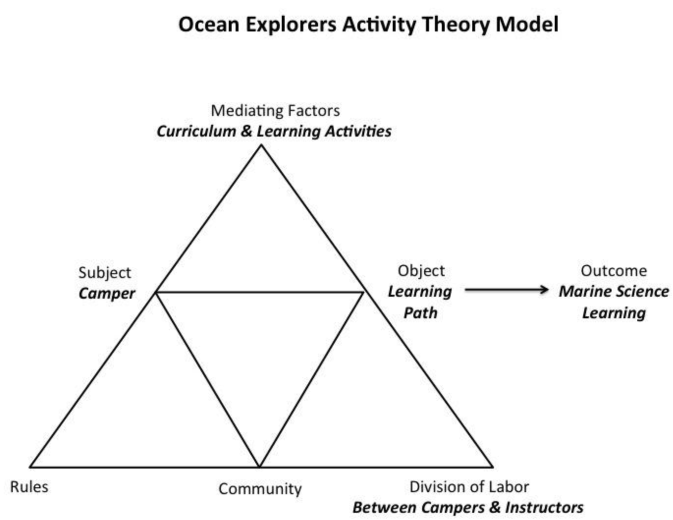

Figure 1: Model for Activity Theory at Ocean Explorers Camp.

Results

Case 1: David

David was a seven-year old, white male and a rising second grader. He was young for his grade, having turned seven the week before camp began. He was the only camper who listed any misconceptions on his Day 1 knowledge inventory; he cited “sea monsters” as something he knew about the ocean. During the focus group interview, when asked to show the notebook entry he felt was his best work, David selected the page shown in Figure 2.

Figure 2: David’s best work notebook entry

David told the moderators that he put a lot of work into these entries, and explained the activities done to prompt those entries. On the right side of the page, David glued down samples of beach sand and local soil after comparing the two substances in an activity on Day 1. On the left side, David drew a diagram of model plankton he created during an activity on Day 2 of camp. When asked what he learned in those lessons, David first pointed to the sand and soil samples and noted that sand was “shinier” than soil, and that sand was found in different places on Earth than soil. He moved on to the plankton drawing and noted that his plankton floated because it was light. When David was asked why he wrote and drew these things, he replied that he wanted to remember what he did, and that he wanted to “be like a scientist.” When asked if there were alternative ways to represent these thoughts, David was certain that this entry was the only way to represent these ideas while, “being like a real science person…like a grown-up.” He also explained the importance of keeping his notebook “nice” so that people know that he takes care of things.

David was asked to share the notebook entry for the activity that was hardest, and he had a tough time pinpointing one activity. Prompted by another child's response, David decided to present the entry shown in Figure 3.

Figure 3: David's hardest notebook entry.

The page shown in Figure 3 corresponds to an activity from Day 1 in which the children created model seafloor features in a clear plastic shoebox, added colored water at varying depths, and traced the borders on a transparency sheet creating a topographic seafloor map. David thought this entry was hard because it was difficult to draw the contour lines on the transparency sheet, especially as the water approached the surface. When asked what he learned that day, he shared that he learned that the seafloor had rocks and boulders, and that the ocean was three miles deep in places. He wondered aloud about what it would be like to explore the deep ocean in a submarine. As with his best work example, David was certain that drawing was the only appropriate way to represent his ideas.

On the last day of camp, David produced a knowledge inventory with longer entries than on the first day (i.e. most of the items he listed on Day 1 were one-word items), without any misconceptions. His post-inventory included information covered during camp activities such as: "Jellyfish are plankton," and "There are many different kinds of fish." From the interview, we found that David was able to orally describe the things he learned about marine science in a much more complete way than he could either through his knowledge inventory or through analysis of his notebook entries alone. For example, David orally explained how both beach sand and local soil could be carried in one's hands, while he simply documented "you can take it anywhere," in his notebook entry.

Case 2: Jason

Jason was eight years old and a white, male rising third grader. On his initial knowledge inventory, Jason listed factual information about what could be found in the oceans (e.g. sand, mammals, plants, coral). During the focus group interview, when Jason was asked to identify his best work, Jason chose the page pictured in Figure 4.

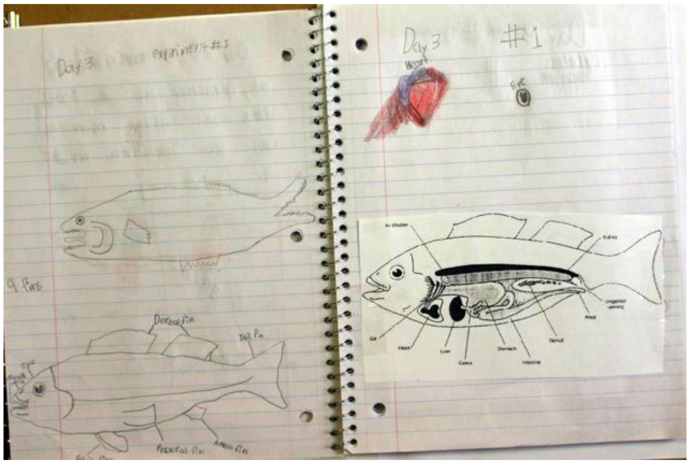

Figure 4: Jason's best work notebook entry.

Jason explained that during the activity corresponding to Figure 4, the class dissected fish. Jason reported that he learned about the functions of different fins, the location of the bones, and the fact that the brain was "squishy" and hard to access. His favorite parts of this entry were the drawings. When questioned about why some of his drawings contained color while others did not, Jason replied that the heart was more than one color, and divided into three pieces, so he felt it was important to show that difference. He noted that if he had time, he would have used color in more places. Jason decided to draw these images because he thought they would look good in his notebook. When asked for some other ways to represent these thoughts, he replied that he could have also written about the fish.

Jason also had difficulty choosing an entry that was hard for him, and acknowledged that it was difficult to keep up with the entries when camp was busy. After some discussion, Jason chose the entry pictured in Figure 5. Coincidentally, this entry is from the same activity with which David had the hardest time (see Figure 3).

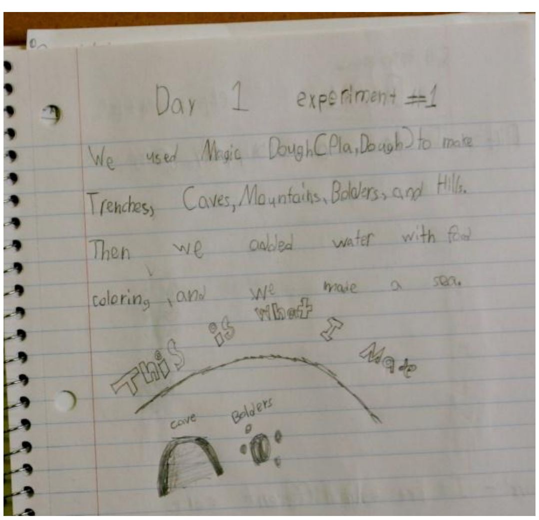

Figure 5: Jason's hardest notebook entry.

Rather than drawing the entire model of the seafloor and topographic map, Jason chose to draw the models of the features he created (caves and boulders), and describe the day's activity as "making a sea." When asked why he didn't draw the "sea" or the map of the sea, he noted it was difficult to draw the map and it didn't come out as he expected, so he chose to leave that out.

Jason's Day 5 knowledge inventory, was twice as long as his Day 1 inventory (10 items versus 5) and articulated many new things about marine geology and biology (e.g. "Fish have a fin that is like a brake."). He was also able to describe these things during the focus group interview and in his notebook. However, because of his hesitance to record things that weren't "right," his notebook alone does not provide an accurate record of his complete learning path. On the other hand, when his notebook data is coupled with his interview, we are able to better describe the path of his learning.

Case 3: Rose

Rose is a female, seven-year old, rising second grader attending camp on a half scholarship. Early on, Rose identified as a scientist, and reported to the camp staff on experiments she did at home. She was the most skeptical of the campers, and came to camp with the most background knowledge in marine science, which she documented on her knowledge inventory (e.g. geographic locations of the world's oceans, and list of photic zones in the ocean) When asked to select the entry that represented her best work, Rose chose the entry pictured in

Figure 6.

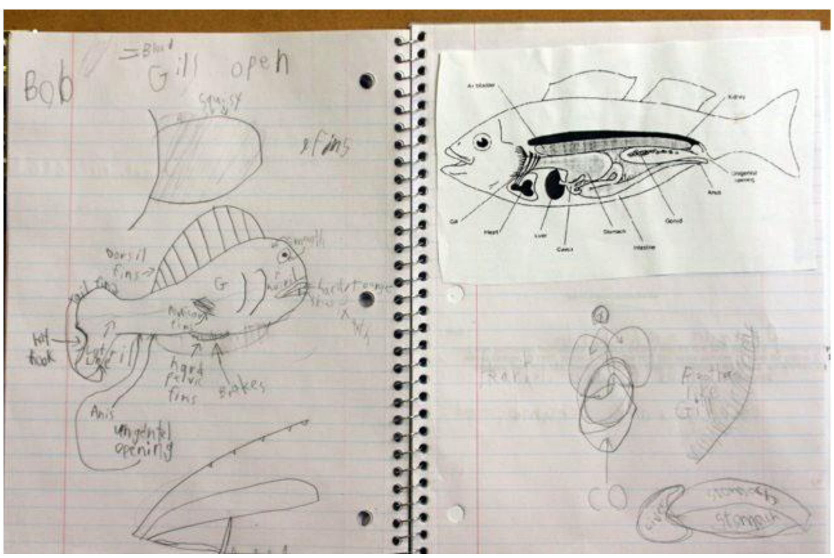

Figure 5: Rose's best work notebook entry.

Rose's best work entry is from the same activity Jason chose for his best work example (see Figure 4), the fish dissection activity from Day 3. When asked what she liked best about the entry, Rose shared that she liked the, "close ups" of various parts of the fish's anatomy because they show the details of the various fish body parts. Although she chose to participate only in the exploration of the outside of the fish, Rose interviewed the other campers and the camp director about what some of the internal fish organs looked like, thus the close ups of the heart, stomach, and liver on the right side of Figure 6. Rose could not think of any other ways to represent her thoughts, but said she learned the fish's brain was "squashy" and acknowledged that she could have added this detail.

When asked which notebook entry was hardest, Rose selected two. The first was a diagram of her plankton model, and Rose thought this was difficult to draw because of the detail involved with drawing all of its parts. She also struggled with the entry pictured in Figure 7.

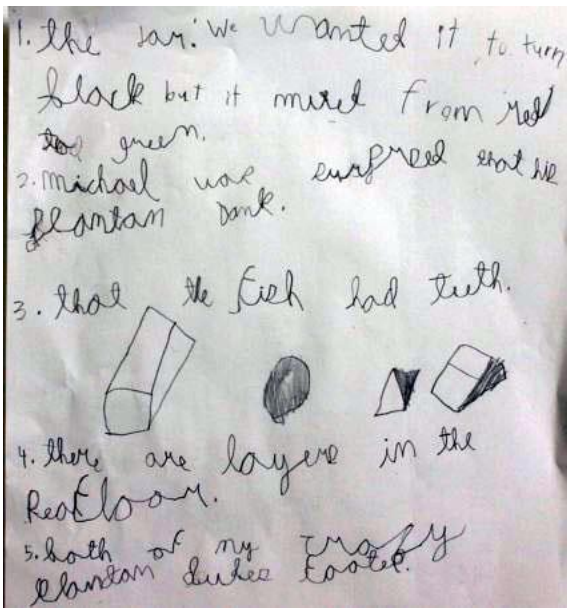

Figure 7: Rose's hardest notebook entry.

The entry in Figure 7 was not done directly in the notebooks, but on a separate sheet of paper that Rose chose to keep in her notebook. In this activity, which took place on Day 4, the children were asked to reflect on some of the things they had learned during the first three days of camp. Rose struggled with this entry because it was difficult to think of all the things she had learned. When asked about whether there were any other ways she could have shown her thoughts for either of the entries Rose found hardest, she was unable to think of any.

Rose's Day 5 knowledge inventory was nearly twice as long as her Day 1 inventory (9 items versus 5). On her Day 5 knowledge inventory, Rose reported on specific things she learned throughout the week at camp such as that there were layers of the seafloor and more than 400 species of sharks. Generally speaking, she used her notebook as a tool for reflection or comparisons more than the other campers, though, like her peers, Rose was able to describe more of what she learned about the oceans verbally than she was through writing or drawings in the notebook.

Discussion

Three key themes emerged when constructing the cases of David, Jason, and Rose. These were: 1) preference for concrete representations of scientific phenomena over the abstract; 2) the children each followed unique learning paths; and 3) knowledge gained at Ocean Explorers Camp was often socially constructed.

Concrete versus Abstract Representations

The science notebook entries that students described as their "best work" were extremely concrete in nature. Given the age and developmental stage of the campers, which Piaget would describe as *concrete operational* (Piaget, 1958), this finding was consistent with most accepted views of child development. The selected "best entries" were the ones in which campers created realistic images of their activities. These entries included drawings (of the fish as well as of the plankton), and artifacts from the activities, such as David's glued down sand and soil samples. The children were able to explain these activities fairly easily and neatly. Only Rose's notebook entries contained evidence of abstraction shown through comparisons and reflections. This does not suggest that she was the only camper capable of abstract thought. Rather, she was the only one who provided any evidence of abstraction through written and drawn expressions. Further, two of the three interviewees had trouble creating the topographic maps and selected these entries as those marked hardest for them to do. This is a task that required visualizing 3-D space from multiple perspectives and representing observed phenomena in a more abstract manner. Piaget's work would suggest that this type of abstract visualization was beyond the scope of the campers' developmental level. Despite this difficulty, with the assistance of instructors both these campers were able to create unique representations of the seafloor maps, as they were given an opportunity to construct meaning socially throughout their learning experiences, as suggested by Foreman and Cazden (1985). Taken together we can conclude that though these children seem to have a preference for concrete representations, when given an opportunity to construct meaning socially in an informal environment, they can describe more abstract ideas verbally. These findings are in concert with Dierking and colleagues' (2003) assertion that informal science knowledge is often constructed through social interaction. Given the very limited amount of time these students have for science in the traditional classroom setting and the typical class size and student-to-teacher ratio, the Ocean Explorers experience might have provided a unique opportunity to engage in this type of meaning making about abstract ideas.

Unique Learning Paths

The informal structure of Ocean Explorers camp allowed students some autonomy and independence in their learning experiences, unlike the more traditional textbook and kit-based science instruction typical of formal elementary science curricula, which tends to follow a fairly narrow arc of instruction for all children. Though all campers improved their knowledge of marine science content in this loosely structured environment, each child followed a unique learning path. This is most evident in the differences we see in students' notebook entries on the same lesson. For example, Figures 3 and 5 were both created during an activity modeling seafloor features, yet each student chose to emphasize different aspects of the lesson David drew the whole model, Jason drew and described individual features. While both David and Jason met the learning goal of modeling seafloor features, their learning paths and representations of learning were quite different. Jason's decision to include just a few of the features suggests that he reasoned about which features were most important in creating his representation of the activity, while David elected to represent the entire system without keying in on specific areas. The children each acknowledged a sense of pride and ownership in their notebook entries, and interest in being a scientist, however the expression of the manner in which they expressed these similar feelings varied among the campers. David expressed an importance in keeping things neat so that people would know he took care of things. This idea of neatness can also be interpreted as a way of communicating individual ideas effectively to the group before coming to a consensus. Rose expressed her frustration in drawing all the details of her model plankton, suggesting that the accuracy of her notebook entries were important to her. However, Rose's notebook also contained an entry documenting the group's two failed attempts at creating layers of dyed salt and fresh water along with a third successful trial in her entry depicting Day 2's water density activity. The inclusion of all three trials in her notebook suggests that it was the important to her to provide a record of all the camp activities, not simply those that turned out successfully the first time. It might also have been important for her to represent the group's attempts at problem solving and the tenuous nature of scientific exploration. Jason, on the other hand, was concerned about having the right answer in his notebook entries along with neatness. He needed to be prodded by the camp director to record information about failed trials after the completion of the water density activity on Day 2. In sum, each camper was able to demonstrate content knowledge gains in line with the camp's learning goals after exposure to the same camp, yet, each camper reached those goals following a unique path. Additionally, each child developed a distinct relationship with their notebook, reflecting their perceived role as scientists and students. Rose, in particular, seemed to recognize that the role of a scientific notebook was to include a complete record of inquiry activities, not just the school-oriented "correct answers."

If we were to map each camper's experience using the Activity Theory Model pictured in Figure 1, we would find some clear differences in the shape of each learner's triangle. For example, Rose relied heavily on the community's experiences and documented some of the whole group's experiences (e.g. the group's failed attempts in the density activity), thus her triangle would be skewed toward the community and division of labor portions. On the other hand, Jason was especially concerned about neatness and the right answers, suggesting that his triangle would be skewed toward rules. Finally, David's triangle would be skewed toward both the curriculum and learning activities, given his preference for documenting the larger context of various activities rather than individual features along with rules, given his preference for neatness. This model helps us describe the factors influencing each camper's learning path more clearly.

The differences among the three campers' notebooks clearly illustrated that each child, while learning within a socially mediated context, was still able to follow a unique learning path in meeting the camp's learning goals. This use of unstructured notebooks, coupled with the flexibility in the camp's structure (e.g. incorporating a student-requested shark fact scavenger hunt) afforded students choices in their learning experiences. This level of student-directed learning is unlikely to occur in traditional elementary school learning settings, given the constraints of time and standards-driven curricula. Furthermore, the students' unique learning paths were around *marine science* content, an area in which they had personal interest (based on their comments during interviews and choice to attend a marine science camp), and is minimally covered in traditional school settings (Cava et al., 2005).

Socially Constructed Science Knowledge

At Ocean Explorers camp, we found that campers typically constructed their knowledge within a social context. Given the small number of campers, most activities were done as a group. On Day 1, the group compared and contrasted beach sand and local soil. Each student shared his or her own knowledge, and these influenced the types of notebook entries that campers created—while the notebook entries were personal, they reflected the intensive social interactions of the camp. For example, the group noted that both sand and soil were light in weight and small in size. This sparked David's notebook annotation of, "you can take it anywhere" as something that the two substances had in common, suggesting that this knowledge was socially constructed. Sociocultural theory also suggests that learning occurs when students work within a ZPD (Vygotsky, 1978; Foreman & Cazden, 1985). At Ocean Explorers, it was possible to structure interactions to keep campers working within their individual ZPD—and doing so allowed the children at the camp to stretch well beyond their independent abilities. For example, during the first activity on Day 1, the campers created 3-dimensional clay models of the topographic features of the seafloor after viewing some images of different seafloor components. Jason saw that David was frustrated and struggling to create some of the features of the seafloor, such as the trenches they earlier observed on a video. Jason acted in the role of more able peer (Foreman & Cazden, 1985), and assisted David in creating model trenches working within David's ZPD. This instance is also an example of abstraction in that the children were able to represent objects bigger than the human scale in a concrete way, pushing beyond their developmental bounds (Piaget, 1958) with the help of their learning community. Social constructivism also suggests that expertise is distributed among groups. For example, Rose decided against participating in the fish dissection during the second half of Day 3's activities, and did not personally explore the interior anatomy of the fish. However, she interviewed each of the other campers and the camp director about each of the fish's organs. Each of those campers became an expert on internal fish anatomy and was able to share their knowledge, exemplifying a distribution of expertise (Brown et al., 1993).

Conclusions & Implications

Though limited in size and scope, Ocean Explorers adds to our understanding of learning marine science content through informal education experiences through three children. These three participants attended a school where science was taught for less than two total hours each week, thus they have few opportunities to interact with scientific phenomena over an extended period of time. Furthermore, the science experiences these children have at school are based on state and national science standards, none of which address content specific to the world's oceans. This standards-based instruction also leaves little room for students to explore ideas outside the mandated curricula. Attending Ocean Explorers camp immersed the children in science content in an area of their choosing and allowed these children to engage in marine science explorations for an extended period of time (20 hours in one week). The students were also given ownership in the camp's direction, and were encouraged to suggest activities and experiments based on their ideas. Our findings suggest that each student enhanced his or her knowledge of marine science content in a manner that followed very different learning paths as a result of participating in the camp. Additionally, they were able to develop more general scientific habits of mind by recording the iterative process of scientific investigation through using their notebooks. While much of the literature on informal science experiences focuses on attitudes and beliefs about science (e.g. Gibson and Chase, 2002; Ramey-Gassert, 1997; Rath & Brown, 1996), our findings highlight the value of informal science experiences for increasing students' content knowledge *and* created more positive attitudes and beliefs about science, and are in concert with those of Farmer and colleagues (2007) and the Center for Public Program Evaluation (2009).

We can return to our initial research questions examining how this week-long camp experience changed the campers' understanding of marine science content, and what the learning paths were for the three campers, and conclude:

- *Each camper followed a unique learning path, illustrated in their varied notebook entries.*

Though all of the children demonstrated gains in learning about marine science content with respect to the learning goals of the activities, their learning as documented in science notebook entries and discussions followed unique paths. These unique paths were facilitated by the more unstructured nature of the informal learning context.

- *Ocean Explorers campers constructed knowledge socially.*

Each of the three campers used his or her fellow campers' knowledge and expertise to guide their own learning. They, in turn, used their knowledge to help others with their learning.

- *Ocean Explorers Camp was a useful mechanism for enhancing each child's marine science content understanding.*

Our multi-case study of three campers from Ocean Explorers revealed that each of the three campers knowledge of marine science content was enhanced.

Some additional conclusions beyond the scope of our initial research questions can also be made. We found that the campers were able to document their marine science learning in their notebook entries. These entries varied considerably from camper to camper and though they certainly were not exhaustive records of the students' learning, they allowed us to make more complete comparisons construct more complete narratives of the campers' learning paths. Finally, we found that on the whole, students were most comfortable documenting and describing concrete scientific phenomena via their written and drawn notebook entries and their verbal discussions during interviews. Though there was some evidence of abstract thinking in the notebook entries, student interviews/discussion were necessary to draw this abstract knowledge out of children of this age.

Future Work

A second iteration of the camp will take place during a future summer, with a larger group of campers and the study will be repeated to determine whether similar learning gains in science content are shown.

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