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Children's Ideas About Animal Adaptations: An Action Research Project

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In this paper, I describe the action research I conducted in my third-grade science classrooms over the course of two years. In order to gain an understanding of my third-grade students' ideas about animal adaptations and how the teaching of a unit on crayfish influenced these ideas, I used clinical interviews, observations, and written assessments. I did this research while working as a science resource teacher in a suburban elementary school. The first year, I piloted the unit myself and then made changes to the unit based upon my findings. During the second year, the entire third-grade team taught the unit, and I co-taught with one of these third-grade classroom teachers. I found that students' ideas are developing and that connections to other parts of the science curriculum such as habitats, gases, and plants were necessary yet lacking. Teachers should be prepared to understand these connections themselves and to highlight them to students. Also, as other research indicates, a complex understanding of adaptations is difficult and perhaps not developmentally appropriate for elementary students. Teachers should recognize that elementary students will not develop an understanding of adaptations from merely working with and observing animals in their habitats. Further research is needed to see if the students need specific lessons on adaptations, an understanding of evolution, and/or more experience and maturity in order to truly understand the concept of adaptation.

Theoretical Framework

Research informs us that children actively construct their understanding of science through individual and social processes (NRC, 1996). Because of this, children's explanations for scientific phenomena are sometimes different from scientific views (Driver, Squires, Rushworth, & Wood-Robinson, 1994). These differing explanations are called alternate conceptions (Driver et al., 1994; Wandersee, Mintzes, & Novak, 1994).

In order to address alternate conceptions and to help children construct scientific knowledge, the *National Science Education Standards* encourage teachers to create learning communities in which students actively engage in pursuing their own questions (NRC, 1996, p. 4). Students must feel safe expressing their ideas so that their knowledge construction is apparent to the teacher (Brooks & Brooks, 1993), so the teacher can scaffold the child's ideas (Fleer, 1992; Shepardson, 1999).

Carey (1985), using a Piagetian perspective, suggests that around the ages of 9 to 10, children have accumulated enough biological knowledge to undergo conceptual change or what Carey refers to as a "strong restructuring" of biological knowledge (p. 3). Carey believes that prior to this restructuring, children explain living functions using a "naïve psychology" in which bodily functions and natural phenomenon are explained as being controlled by human desires (i.e., we sleep because it is our bedtime or the sun shines to keep us warm). As children's biological knowledge undergoes conceptual change, they begin to replace these naïve psychological explanations with biological explanations. As third graders, my students seemed ready to develop a more complex understanding of the four concepts I wanted to teach them.

The first concept that we studied involved the students' understanding that a habitat contains a variety of living and nonliving things. Prior to age 9, young children tend to use movement to classify objects as living (Carey, 1985; Wang Dai, 1995) and inanimate human-made objects as nonliving (Tamir et al., 1981). They are often more likely to identify animals as living and plants as nonliving (Leach, Driver, Scott, & Wood-Robinson, 1992; Stavy & Wax, 1989). By age 9, however, students start to change their framework and use a variety of biologically acceptable ways to classify organisms (Bell & Barker, 1989; Carey, 1985). Around the age of 6, young children understand that animals and plants are living in a habitat, but they can only differentiate between habitats that are extremely different (Strommen, 1995).

The second concept that I wanted the students to learn was that all organisms have basic needs. From an early age, children believe that food or absorbing materials is necessary for growth in animals. They also believe that plants need light, food, and soil to grow; however, a common misconception among children, as well as adults, is that plants use soil as food to grow (Driver et al., 1994).

The third concept that I wanted to teach was that animals have structures with different functions for growth, reproduction, and survival. By age 10, children move from viewing body parts as having a psychological function (the heart is for loving) to a biological function (the heart is for pumping blood) (Carey, 1985). It is also not until age 10 that children are receptive to learning that an organism's structures all work together (Caravita & Tonucci, 1987).

The last, most complex concept involved having my students learn that animals' structures and behaviors are adaptations to their environments. In order to understand the concept of adaptation, students should understand the connection between habitats and adaptations. A study of first graders showed that students do not have the correct conceptions of which animals live in which habitats (Strommen, 1995). This improves as students mature. In a study by Leach et al. (1992), children ages 11 to 16 were able to relate features of an organism to specific habitats and could predict the habitat of an organism. The American Association for the Advancement of Science (AAAS) (1992) recommends that students in third to fifth grades should be able to understand that certain organisms survive well in certain types of habitats and that changing that habitat could harm the organism (p. 123). Despite this expectation of increased understanding, research indicates that older students who are 12 to 14 years old still believe that organisms can change their structures to adapt to a habitat or that they can simply seek a more favorable habitat (Engel-Clough & Wood-Robinson, 1985).

Description of the Project and Teaching Strategies

In this unit, the students observe live crayfish structures and behaviors. They learn the functions of crayfish structures, and they also design their own experiments, which will answer their questions about crayfish behaviors. Based upon my findings from the first year of teaching this unit to all of my third-grade students (N=100) in the science resource lab, the third-grade teachers and I made changes to the unit. These included a special design activity and an introduction to habitats in addition to the students creating crayfish habitats. The teachers also decided to teach a social studies unit on different environments in conjunction with this unit. In the second year, I was a participant-observer as I co-taught this unit with a third-grade teacher in her classroom.

Design and Procedures

I used an action research model (Carr & Kemmis, 1986) to complete this study. I wanted to answer a question directly related to my own classroom, make changes, and then explore if these changes were effective or not. I used a qualitative case study design (Merriam, 1998) in which the crayfish unit and the students' ideas formed the "case."

My research question was, "What are the students' conceptions of the specific life science topics, and how are they influenced by the teaching of a unit on crayfish adaptations?" These life science topics included Concept 1: Habitats contain a variety of living and nonliving things; Concept 2: All organisms have basic needs; Concept 3: Animals have structures with different functions for growth, reproduction, and survival; and Concept 4: Animals' structures and behaviors are adaptations to their habitats.

My data sources included clinical interviews, with a stratified purposeful sample (Patton, 1990) of children before, during, and after the unit; observations of lessons; and students' work, including concept maps, questionnaires, drawings, and journals. For the interviews, which were all audiotaped and transcribed, I used a structured clinical interview (Ginsburg, 1997), which was developed using Ginsburg (1997) and Driver et al.'s (1994) work as well as the research literature on alternate life science conceptions. The interview questions went in order of concepts. For the first concept, living and nonliving, I asked the students to look at an aquarium with snails, fish, and elodea and tell me what was living and what was nonliving. I then asked them to draw a habitat and label the living and nonliving things. For the second concept, basic needs of organisms, I asked them to describe the basic needs of the animals and plants in the aquarium and their drawings. For the third concept, animals have structures with different functions for growth, reproduction, and survival, I showed the children different pictures of wild animals and asked them to compare the legs of animals and speculate on why they might be different. I also asked them questions about the food these animals in the pictures ate, and why they thought this might be the case. I asked them to refer to the animals in their pictures and describe their structures and functions. For the fourth concept, animals' structures and behaviors are adaptations to their habitats, I asked the students to imagine that the animals they drew were moved to a different habitat and that the animal could magically change. The students then described these changes. I then showed students pairs of animals and asked them to speculate about what would happen if the habitats of the animals were switched and how their new structures would help them live.

I used several assessments for the document analysis of students' work. One was a pre- and post-unit questionnaire designed by the third-grade teachers, which asked about the crayfish's structure, functions, and basic needs. The students used concept maps (Novak & Gowin, 1984) throughout the unit to map the elements of a crayfish habitat and its needs. They also made these concept maps for any animal of their choice to see if their learning transferred to other animals. Next, the students had to formally design a crayfish habitat and experiment. I used these designs as an assessment. Lastly, the students drew and wrote in a journal throughout the unit.

Data analysis codes (Miles & Huberman, 1994) were developed from the research literature on alternate conceptions as well as inductively. Transcripts of all interviews and observations as well as documents were coded. Codes were tabulated to see the quantity of and patterns to students' conceptions.

Results

First-Year Findings and Changes

Ways Children "Figure Out" Adaptations

During the first year of the study, I discovered that students had different approaches to explaining how a structure matched a function or how a structure or behavior might be an adaptation. Some students used prior knowledge. For example, when I asked Chris to relate a bird's beak to its diet, he stated, "Well, we always saw these guys (robins) digging in the ground" (interview 3/9/98). Other students, such as David, relied upon logical clues. For example, when I asked David why an ocelot has small ears, he hypothesized, "I think the ocelot, with its small ears helps it run faster. Since they are smaller and it's pointed sort of like an airplane's wings. So it cuts through the wind and allows it to go faster" (interview 3/9/98).

I thought that this was an interesting skill that David had developed. I wanted my other students to be able to exercise this, so I developed an activity in which the students designed their own pollinator and flower. It could be any design they wanted as long as the concept of pollen being transported and received was considered. The students enjoyed this activity, and it gave them greater confidence to be creative.

Students' Views of Habitat Differences Limited to Temperature

For the questions in which I asked students to imagine switching an animal's habitat, the students thought the animals would be bothered only by temperature changes. They never mentioned other factors. This led me to add an introduction of habitats to the next year's unit, so students could see that there are multiple variables in a habitat that could affect an animal.

Students Very Receptive to Learning About Behavioral Adaptations

The frequency of discussions related to crayfish behavior greatly increased throughout the unit, both in class and in interviews. This is partly because they are so interesting to observe, but it may also have been due to the fact that students were allowed to pursue their own questions about crayfish behavior by designing their own experiments. This was a time-consuming activity; however, it was worthwhile not only for the inquiry experience but also, as my data showed, for the greater awareness of animal behaviors. Thus, we decided to keep this part of the unit.

Second-Year Findings

For the first year with this project, I was only able to address the most obvious changes that needed to be made. For the next year, I was able to dedicate more time to the research and analysis of this project as I co-taught the unit with another third-grade teacher.

Concept 1: Habitats Contain a Variety of Living and Nonliving Things

At the beginning of the unit, students went outside to observe a habitat contained in a Hula-Hoop™. They recorded their observations and then discussed them. They also read about crayfish habitats. Classroom observations, documents, and interviews revealed that the students understood animals and plants as living things and a part of habitats; however, at the beginning of the unit, students rarely identified the nonliving components of the habitats such as air, soil, and sun.

When given a variety of things to classify, students were able to correctly classify many living things, although there was some debate in their small groups about what parts of a plant should be considered living. The students had to defend their ideas in their small groups and had to develop criterion for this defense.

Concept 2: All Organisms Have Basic Needs

The students were required to research a crayfish's needs and then design a habitat that would keep it alive. The students had to do research to complete these designs. Their design plans were used as an assessment along with the concept maps, interviews, and classroom observations.

At the beginning of the unit, the students knew that animals needed food but did not understand that it comes from other animals and plants. When I asked one of the students to hypothesize about what a camel might eat, he said, "Camel food? Like bread?" (interview 9/22/98). Also, when designing the crayfish habitats, they often did not include plants or other animals. This was not really helped by the fact that the crayfish were kept in artificial habitats and given prepackaged food; however, after giving the students a reading activity on the crayfish's diet in the wild, their understanding greatly improved. By the end of the unit, the concept maps and interviews revealed that the students understood that food would come from other animals and plants.

At the beginning of the unit, the students were not aware that air was a need of animals and plants. Air was rarely listed on the pre-unit questionnaires. While observing the crayfish, the students were fascinated by their bubbles. The students became aware that air exists in habitats, as seen by post-unit concept maps, but they did not develop a consistent idea of air being needed by animals and plants. Interestingly, they often did not identify a crayfish's need for air, and they did not understand that air was in water. When asked about their gills, students would say, "They need gills to breathe water" (observation 11/30/98). From reviewing classroom transcripts, I learned that we really did not actively scaffold the children's curiosity about bubbles into a discussion about air in water and the needs of aquatic animals. This is probably the reason for the students' confusion.

Concept 3: Animals Have Structures and Behaviors with Different Functions for Growth, Reproduction, and Survival

The students initially were asked to hypothesize about the functions of the structures. They were not able to do this for many of the structures, so they were then given a directed reading assignment. They also thought that the crayfish would have human structures such as eyelids and noses. By the end of the unit, the students were able to identify the crayfish's structures and functions; they were also able to hypothesize about other animals' structures and functions, and they no longer placed human structures on animals. The students were able to clearly describe the reason for a female crayfish's swimmerets holding her eggs, and they saw that this structure matched its function. For example, one student explained, "This crayfish is the female. It has more swimmerets. If an egg falls, it would be caught by these swimmerets, but if this one had babies, which I doubt it would because it is a male, if an egg fell out, it wouldn't be able to catch it" (interview 4/27/98). Witnessing the female crayfish hold her egg sac and then have the eggs hatch was a memorable experience that helped the students learn about reproduction as well as structure and function.

When the unit began, the students rarely listed animal behaviors on any of the pre-unit assessments; however, as soon as they started observing the crayfish, they were describing behaviors, usually with anthropocentric feelings attached: "He's scared; he wants a bigger tank" (observation 10/23/98). The discussion and inclusion of behaviors on documents increased throughout the unit. By the end of the unit, students were describing the catching of prey (interview 11/30/98) and migrating (observation 10/20/98). The students not only observed animal behaviors, but they answered their own questions about these behaviors by designing their own experiments.

After the experiments, the students became even more detailed in their descriptions of behaviors such as "It burrowed and covered itself with sand"; "Some males chased females back into the water"; and "They walk sideways" (observation 12/14/98).

Students retained an anthropocentric view of animal behaviors at the end of the unit. When asked what would happen to a goat placed in a rainforest, one boy answered, "Maybe the other animals would pick on it and it wouldn't fit in" (interview 12/16/98). In fact, by the end of the unit with the crayfish, the students were describing more human emotions to the crayfish such as happy, sad, and mad (concept maps).

Concept 4: Animals' Structures and Behaviors Are Adaptations to Their Habitats

This concept did not improve throughout the unit, even with the addition of the habitat component. I assessed the students' knowledge about this during clinical interviews. When asked what would happen if animals switched habitats, students knew that they would not survive as they currently are, usually attributing an animal's potential difficulty to temperature differences. In order to survive, the students knew that the animal would need to be different. One student said a dolphin that moved to the North Pole would "grow some fur if a genie gave him wishes to do that" (interview 9/22/98), while another said a beaver would "lose some fur and grow longer legs so that he could catch more fish" (9/22/98). As seen from the majority of interviews and observations, most students could not offer an explanation as to why an animal survives in its habitat beyond being "used to" the habitat. For example, when asked what would happen if a beaver was moved to the ocean, one girl stated, "He lives in freshwater with mud in it, not sea water. He wouldn't be used to it" (interview 12/16/98). Students knew that animals would not fare well in different habitats, but they were not able to describe all the differences in habitats, structures, and behaviors that connect together. There were several examples of students connecting a structure's design to its functions. For example, when asked how eyestalks helped the crayfish, a students said "It sticks out like a periscope" (observation 12/9/98). We discussed what structures did, but we did not discuss how structures help in a particular environment enough. The results from the second year of the study were the same as the first year, despite adding more information on habitats to the unit.

Discussion

In order to understand animal adaptations, teachers need to teach about habitats concurrently with units on animals and plants. Understanding adaptations to habitats requires a focus on the nonliving factors in a habitat such as the needs of plants. To do this, teachers themselves should have a clear understanding of these factors (e.g., light, air, water, and soil) so that they are prepared to scaffold children's ideas at opportune times. Understanding these factors is developmentally appropriate for upper elementary age students, and teachers should be prepared to teach them. For example, during our teaching of this unit, we missed an opportunity to teach the students about air when they noticed the crayfish blowing bubbles.

Upper elementary students are also capable of understanding the needs of plants. Since plants and their needs are important to understanding habitats, discussion of this should be infused into the animal adaptations unit, not just confined to lessons on plants. Discussions of plants will also help students understand that they are a major food source for many animals.

Teachers should be aware that students' lack of connection with their own food sources (it comes from a supermarket, not a farm or wild habitat) will influence their understanding of animals' needs. Food chains, what animals eat in the wild, and humans' food supply should be included in the curriculum in order for students to learn about habitats and adaptations that help animals eat.

My students were very receptive to learning about the functions of structures and behaviors. Elementary students gain a great awareness of the structures, functions, and behaviors of an animal when they are encouraged to observe an organism over extended periods of time and when they supplement observations with reading and research. My students were even able to connect the design of structures to their functions. An activity such as students creating imaginary pollinators and flowers whose structures worked together helped students make these connections. Teachers should use activities that help students create models for matching structure and function in order to improve students' understanding of these concepts.

My students became particularly adept at describing crayfish behavior but retained an anthropocentric viewpoint. Teachers should be prepared to address this alternate conception through discussions and activities that illustrate the uncertainty of knowing if animals have the same emotions and social interactions as humans.

The concept of adaptations was just beginning to emerge for my students. Students knew that certain animals only survived in specific habitats. This was usually attributed to a temperature difference and/or an animal "being used to" a habitat. Students were not aware enough of habitats and their differences to make complex connections. The students' observations of animals and habitats, experiments, and readings were not enough to help students make these connections. In addition, all the research on this topic points to a complex understanding not being developmentally appropriate for this age group. Perhaps if specific lessons addressed the concept of adaptation and the connections necessary to understand it, elementary students may be able to have a deeper conceptual understanding of adaptations. Further research is needed to see if this is the case or if students are not developmentally ready for this.

Compared to the research literature, my students at ages 7 and 8 seemed to do as much if not more than the literature suggested that they could do especially with regards to structures, behaviors, and functions. This suggests that with strong, inquiry-based, and frequent science instruction at the elementary level, students may be capable of more than our current body of alternate conceptions research suggests; however, teachers need to be mindful of developmental appropriateness. Young children may lack the cognitive maturity and life/academic experiences needed to truly understand a concept. Thus, we may waste valuable classroom time and discourage our students if we continue to teach a concept that is not developmentally appropriate. Teaching preservice and inservice teachers to look at research literature on alternate conceptions and to conduct their own action research will help them make decisions about what they should and should not teach to their elementary students as well as how to improve what they decide to teach.

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