CHIPMUNCKS FOOD CACHING AND FEAR OF PREDATION

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Introduction

Foraging theory provides a framework for addressing the question of how an animal should seek its food while not becoming food for its predators (Brown 1992). When food occurs patchily, a forager can influence its safety by the way it allocates time among food patches that may vary in predation risk. When the most profitable feeding patch incurs the least risk then this patch should be favored over all other patches. Observational and experimental evidence suggests that predation risk is higher for fox squirrels in the open than bush microhabitat. However, the cost of food caching have not been evaluated. Here we will present evidences to accept or refute the hypothesis that seed caching will go toward the forested area whether the food source is outside or inside the forest. In addition, the cost of caching will be measured by comparing nuts left and nut dispersal distances when nuts are placed inside or outside a forested area.

1. **Question:** Where do squirrels have fear of foraging, inside or outside of the forest?
2. **What do you hope your students will learn about inquiry ?** I hope that the students: will understand components of foraging ecology, such as animal fear and the effect that fear has on animal behavior; begin to think critically and develop problem solving skills. These are important because if you "teach each student to make good decisions and equip them to improve their own futures, then they become contributing members of society (Facione 2011)."
3. **What are the hardest parts of inquiry to apply to your classroom? Avenues to overcome these barriers.** The hardest parts to integration are the student's interest and timing. I was able to implement this inquiry in four days, one hour each day, which gave the students time to think about the problem and come up with fascinating new questions on the fourth day. However, for the first three weeks (I implemented this activity with the summer camps at the Brookfield Zoo), it did not work: in part because the animals were not afraid and were eating the nuts in place (therefore, no distance measurements were taken), in part because it was raining almost every day (and we could not go out in the allotted time to make measurements), and in part because I have not included yet other integration components to the learning process, e.g., I added making a map of the collection sites using a compass to have the visual and/or kinesthetic learners' interest. This map was used on the fourth day to compare data that was collected during the week and to view and compare results inside and outside the forest.
4. **What are the hardest parts of integration to apply to your classroom? Avenues to overcome barriers.** Finding out the way each student learns so that I could implement that integration component to the inquiry activity, and finding out what is exiting to them. Some students were not impressed with the strings been moved by the animals. They were probably hoping to actually see the animals. I added several components here: flour, a camera-trap and a laptop. The flour (a tactile component which all of the students loved: to spread flour around the seed traps!) allowed to show the tracks of the visiting animals. A camera trap placed in front of one of the set traps allowed showing them animals that visited the traps at night or early in the morning. I used a laptop to download the pictures and show the campers at noon what the camera photographed the previous day.
6. **What are the best components of inquiry and this process for you and for your students?** Completing the inquiry. They were proud to come up with new questions , and I was thrilled with their new ideas.
7. **What connections to the real world could your students make from the inquiry they will do for this class?** This activity may gradually lead students to an understanding of the similarity of behavior in many different animals. If I question them about the tamarins, for example, as to "how would you apply your experience with the squirrels to these tamarins?" they could come up with ideas on how to study these monkeys based on their experience on scientific skills, observation and data collection that they acquired with the squirrels. In addition, students may decide to do as Peebles' (1994) students who chose to adopt a cotton-top tamarin in the "adopt an animal" program at the Bronx zoo, collecting money to help support that animal. Her students seemed to find it very satisfying to make a connection with the real world this way, which may prompt some of students to continue supporting the zoo in the future.
   Other connection to the real world occur when children gain knowledge and reasoning skills by direct observation, data gathering and using their senses as we walk in the woods. Direct observation is an essential part of mathematical learning that is indispensable for recognizing patterns, promoting problem solving, and developing spatial sense and reasoning (Basille 1999) while looking for patterns. These activities allow

students to draw their own conclusions on the basis of information that they have not collected but have observed with their own eyes. Furthermore, learning about the patterns and habitat needs of animals in the wild is key to conserving species and protecting our environment.

8. **Propose 2 - 3 new questions that might came from this inquiry.** These were questions generated by the campers: How different is the seed dispersal close to the zoo visitors compared to this isolated area of the zoo? Where do foxes bring their prey, to the den or they eat it where they find it? What do squirrels prefer more: hazelnuts, acorns or peanuts? Do squirrels prefer berries to nuts? Do squirrels disperse seeds to urban areas (people's neighborhoods and back yards) differently than they do in the forest? Do squirrels prefer certain building materials to make their nests (leaves, twigs, underbrush)?
9. **What related subject areas can be included in reflection and how will you do that?** Related subjects: Animal food preferences, predator behavior, urban wildlife and human effects on animal behavior. I would use a similar experiment based on the above questions: for food preferences, will offer different types of nuts to the rodents but will present them only inside the forest; for predator behavior, present a killed animal with an attached string and follow where does the predator brings it or if it eats it on site; for urban wildlife and human effects: set up the experiment in back yards and compare results with forest experiments on seed dispersal.

Integration, Subjects :
Art: draw a map of the collection sites
Language/Literacy (Linguistic): vocabulary = predation, fear, seed dispersal, caching.
Math (Logical/Mathematical): count number of hazelnuts taken, measure strings from release point to burial location, calculate total distances.
PE (Kinesthetic): Game to understand foraging theory.
Science: Animal behavior, foraging ecology

Multiple Intelligence Approaches:
Existential = Why are the squirrels afraid of foraging? What is the strategy that they use to avoid predation?
Interpersonal = work together to tally the distances in and out the forest on all locations, count the number of nuts taken on each location in and out of the forest (group discussion).
Intrapersonal = create your own map, observe where do you find longer distances on you r map. Naturalistic = outside in nature for this activity

Materials
Game to understand foraging theory: transparent marbles (about 3 cups of them) , two plastic containers (20 x 10 cm), several big plastic beads of 2-4 cm length each so that they are visible through the transparent marbles.
Squirrel experiment: Gravel (5 buckets), plastic trays (30 x 20 x 15 cm; two for each site), each site with an area inside and another outside a forested area, spools of thread (Cansew Inc., polyester cocoon bobbins, 48/31 # 10W), epoxy to glue hazelnuts to strings, 50 plastic canisters (from developing film in Jewel-Osco, Wolf Camera) to place the bobbins of thread, compass to determine direction of seed caching, laser meter (or ruler) to measure distances.
Mapping: compasses (at least one for every 2-3 students or one for each student), markers (one for each student) and white cardboard (one for each student).
Tracking predators: Two pounds of wheat flour per week, a piece of folded paper for each student to smooth the flour.

Methods:
Game to understand foraging theory: This foraging game is a type of "tag game" that can be used to introduce foraging theory to students. What do squirrels eat? (Nuts, insects). When they are foraging for food, what factors may be making them afraid of foraging in certain locations? (Predation). What types of predators they might expect to find in this location? (Foxes, raccoons). I explained to them that we were going to play the "foraging squirrel game" and one of them was going to be the fox (the tag person). For that purpose, two trays filled with transparent marbles were placed in two different locations separated 20 meters from each other within a wide grassy area. The big colored beads were shown to the students to let them identify the "nuts" that they were supposed to gather from the trays. The same number of colored beads was placed inside each tray before beginning the game. At a sound of a whistle, students run to the trays and got as many "nuts" as possible, while the "fox" chased and tagged them. The "squirrel" that was tagged, perished and sat on the floor. The process continued for about a minute when a 2nd whistle indicated that the first round of the game had ended.

The group gathered to count the number of nuts that were taken from each tray. Since the "fox" had unlimited access to any location, about the same number of "nuts" were taken from each of the two trays. Therefore, the 2nd round of the game restricted the access of the fox to one of the sites. The inaccessible site to the fox had all of the colored beads taken from that tray while the accessible site had only a few beads taken. We discussed the results. When all students realized that sites with predators result in more nuts left on the trays, then we walked to the sites to begin the real experiment.

Squirrel experiment: *Canister preparation*: I placed 2-3 bobbins of thread inside each plastic canister, letting the tip of each thread going through a hole on the lid so that when closed, the canister had 2-3 strings protruding from the lid. Using epoxy, I glued each string to a hazelnut and let it dry for a few hours (Fig 1). The canisters were placed in a box (Fig 2) and I transported them to the field. *Field tray preparation:* In each field tray, I made a slit to insert the canisters so that the animals would not attempt to transport the nuts with the canisters away from the seed trap (Fig 3). Then, I filled the trays with gravel (to decrease easy acquisition of food by rodents). Similar trays were prepared and placed in six different sites inside and outside the forest for each site, with a total of 12 trays.

High (9) and low (3) numbers of nuts were offered to the animals inside (I) and outside (O) forested areas with a combination of high numbers outside (OH), low numbers outside (OL), high numbers inside (IH) and low numbers inside the forest (IL).

Experiment: After three hours of setting up the trays with nuts, the students counted the nuts taken from the trays, measured the length of strings from seed trap to caching point, recorded direction of movement using a compass and documented presence or absence of nuts (sometimes rodents cut the string, eat the nut and leave the string with a piece of nut or move the string away but no remains are at the end of the string).

Time frame: 2 or 3 times a week for 9 weeks

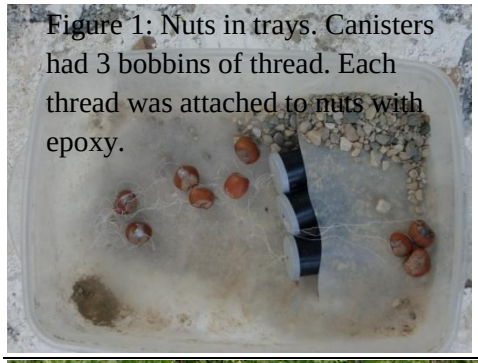


Figure 1: Nuts in trays. Canisters had 3 bobbins of thread. Each thread was attached to nuts with epoxy.

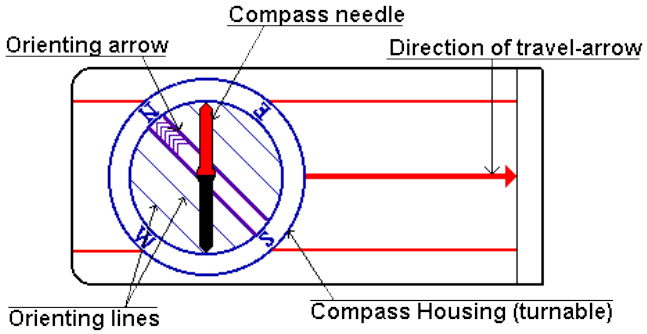
Figure 2: Trays filled with gravel

Trays inside the forest

Outside the forested area (arrow)

Mapping using a compass: On the 2nd day of the activity, each student was provided with a white cardboard, a marker and a compass to make the map. We did a first walk through the squirrel site to have an idea of how the place looked like and to notice relative locations of trees, fences, posts, and other noticeable items. All these items were identified with letters or drawings on the initial map. Then, we began to walk again the site using a compass. The orienteering with the compass included: 1.Align the edge of the compass with the starting and finishing point. 2.Rotate the compass housing until the orienting arrow and lines point N on the map. 3.Rotate the map and compass together until the red end of the

compass needle points north. 4.Follow the direction of travel arrow on the compass, keeping the needle aligned with the orienting arrow on the housing.



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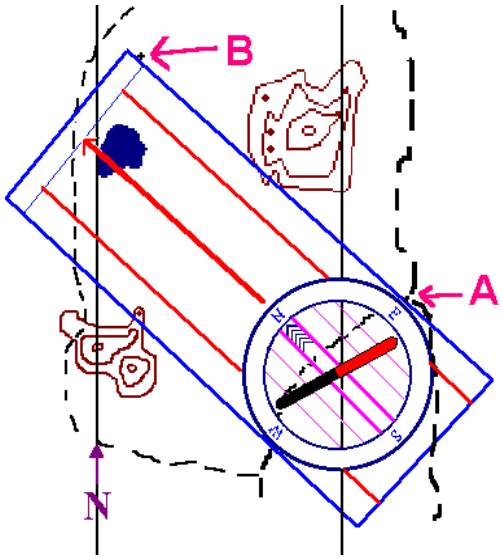
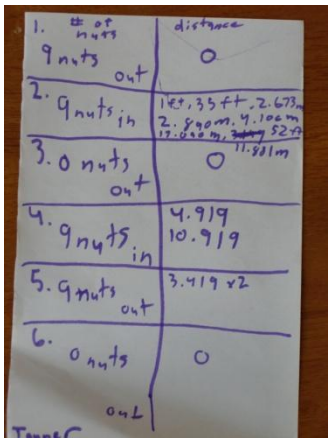


The students placed the compass on one of their hands and wrote down on the map the location of the four cardinal directions while standing at this entrance gate. Then, they placed the compass on the map so that the edge of the compass was at A (entrance gate to the site), and walked to point B. The edge of the compass used was the one parallel to the direction of the travel arrow. Then, they placed location B (a tree or fence that they noticed initially) somewhere along the same edge, as on the drawing. They counted the number of steps that it took to walk from point A to point B and wrote steps on the map. An alternative is to count the number of seconds that it takes to walk from point A to point B. Campers continued doing the same for all points that were initially noticed until they reached the exit of the squirrel site. Additional information regarding trees, plants, or fences that were not noticed on the first walk were added on the map this time.
On the 4th day of the activity, students were gathered on a circle and sitting on the floor, they wrote on the map the total distances that nuts were transferred away from the trays placed inside and outside the forest as well as the number f nuts taken from each tray.



The discussion led to new questions that they were interested on pursuing next time, completing the inquiry cycle.

Tracking predators: On the 3rd day of the activity, the students poured several cups of flour on the floor around each of the trays and smoothed it using a piece of folded paper. The goal was to identify the following day, which animals have visited the trays by looking at the tracks that were left on the flour. This activity provided the tactual learners with an opportunity to enrich their experience. A camera trap was placed at each of the locations for 24 hours to identify which animals visited each location and corroborate the findings using the flour for tracking animals.

Integration Subjects : Art: draw a map of the collection sites ; Language/Literacy (Linguistic): vocabulary = predation, fear, seed dispersal, caching. Math (Logical/Mathematical): count number of hazelnuts taken, measure strings from

release point to burial location, calculate total distances. PE (Kinesthetic): Game to understand foraging theory. Science: Animal behavior, foraging ecology.
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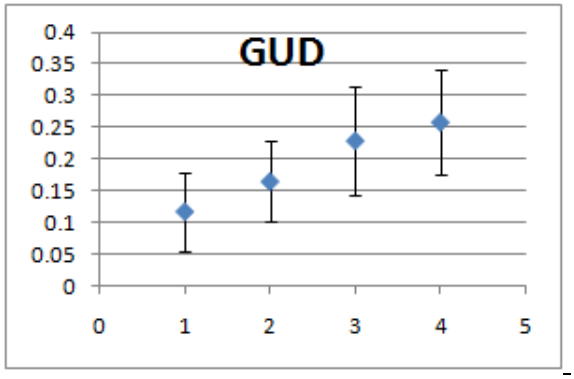
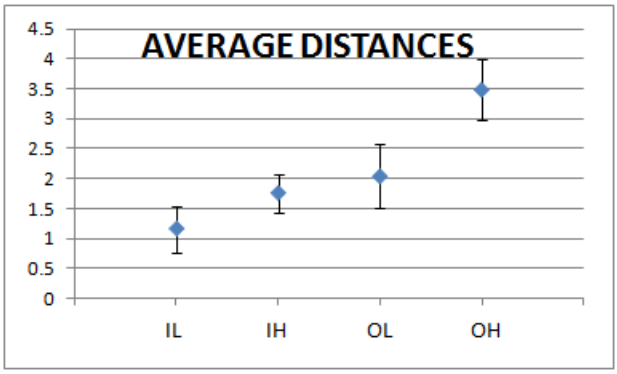
Results

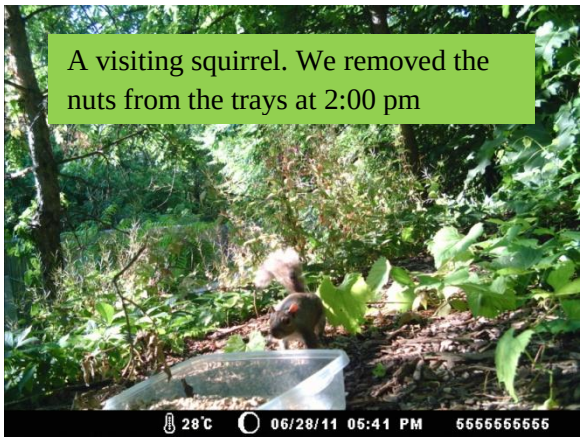
Squirrel experiment



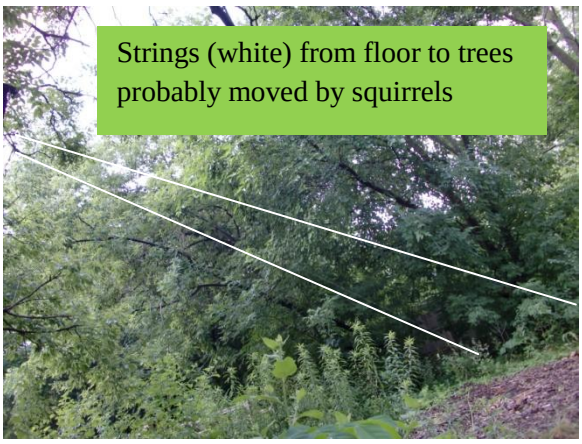


A total of 403 hazelnuts were used for these experiments with 78, 130, 62 and 133 placed in locations IL IH, OL, OH (inside (low and high) and outside (low and high) forested areas). GUDs were not sensitive enough to detect any differences among locations (ANOVA, F = XXX, df = 3; $P > 0.05$). However, seed dispersal distances were significantly different among the four possible locations evaluated. When nuts were offered in high numbers (9 nuts per tray) and outside of the forest (OH), dispersal distances were significantly higher than at any other location. High densities inside (IH) or low densities outside (OL) the forested area were not significantly different from each other but were lower than OH and significantly higher than IL (inside and low densities). Low densities of nuts inside the forest were (IL) were the ones that were dispersed the least simply because the animals were not afraid, the cost of caching was the lowest and most of the nuts at low densities were simply eaten on site. It was not worth the effort to cash 3 nuts. Instead the animals ate them in situ. ().

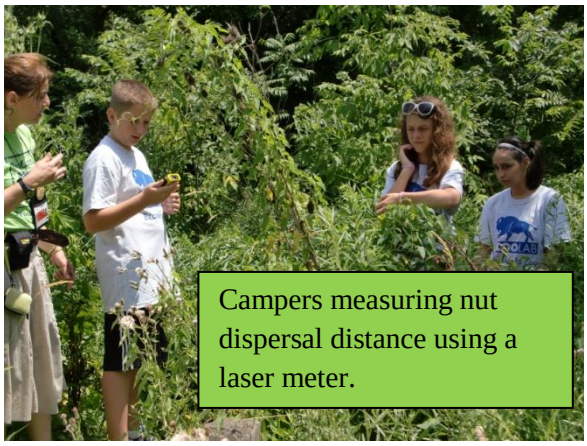
The pictures taken by the camera trap revealed that chipmunks represented most of the seed dispersers in these areas, although an occasional grey squirrel showed up at some sites. However, when squirrels dispersed the nuts, they always carried them to the top of trees and wooden fences that were more than 6 feet tall, which allowed us to separate the squirrels' data from the chipmunk data (line treads were on the floor towards a nest-hole made on the floor).



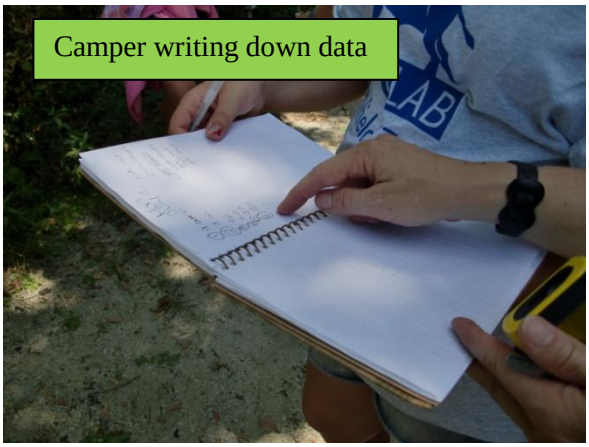
A visiting squirrel. We removed the nuts from the trays at 2:00 pm


Strings (white) from floor to trees probably moved by squirrels


Campers looking for strings

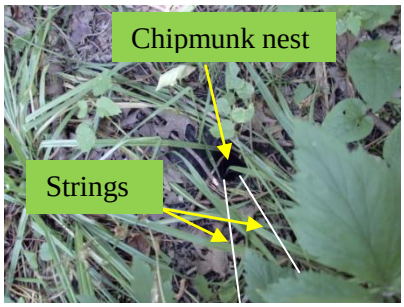

Campers measuring nut dispersal distance using a laser meter.

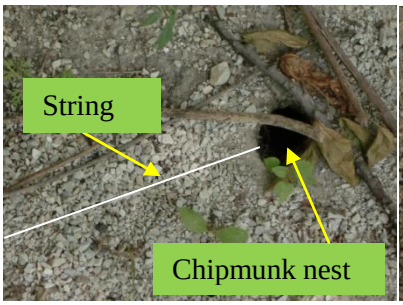

Camper checking for nuts


Camper writing down data

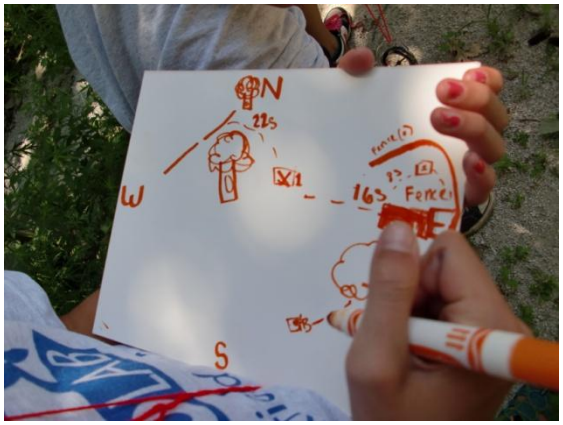

Strings

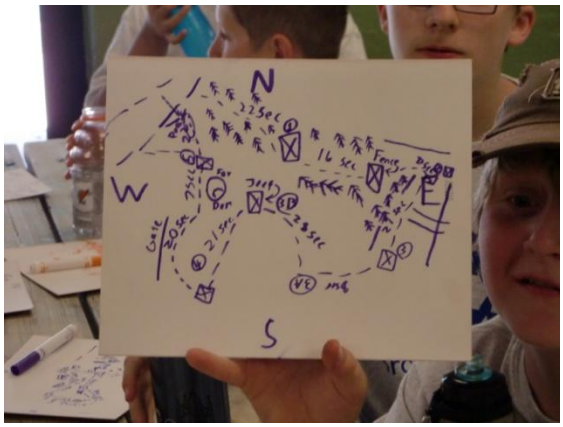

Strings

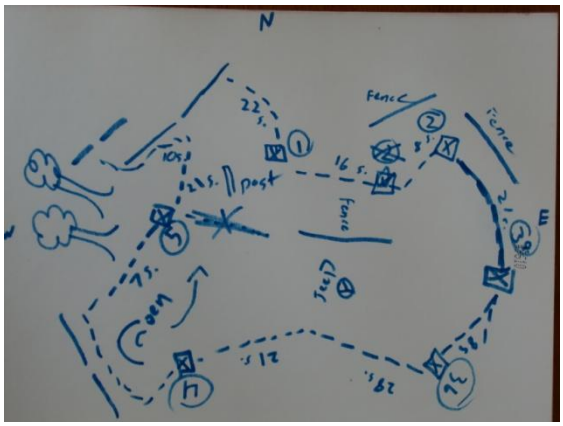




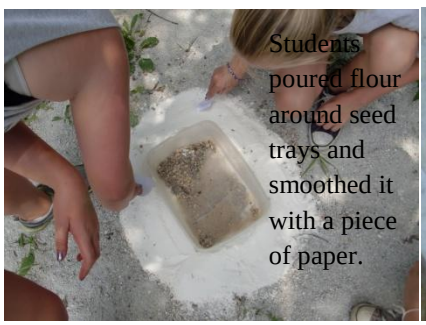
Mapping







Tracking predators


Students poured flour around seed trays and smoothed it with a piece of paper.


Animal Tracks


Animal Tracks


Animal tracks


Animal tracks


16°C 07/08/11 02:19 AM 5555555555


26°C 07/08/11 07:22 PM 5555555555


25°C 06/28/11 07:20 PM 5555555555


22°C 07/12/11 01:03 AM 5555555555


29°C 07/08/11 02:11 PM 5555555555


16°C 07/16/11 03:18 AM 5555555555

New Questions

How different is the seed dispersal close to the zoo visitors compared to this isolated area of the zoo? Where do foxes bring their prey, to the den or they eat it where they find it? What do squirrels prefer more: hazelnuts, acorns or peanuts? Do squirrels prefer berries to nuts? Do squirrels disperse seeds to urban areas (people's neighborhoods and back yards) differently than they do in the forest? Which building materials do squirrels prefer the most to make their nests: leaves, twigs, or underbrush)?

Reflections

Using several subject areas to focus on a particular topic created a multidimensional way to teach content that I have never envisioned or felt before. It has been a phenomenal experience to actually do it with children and see how they grow and learn how to think in a short time. Interestingly, I found that an integrated classroom can actually be used in an informal setting. For example, when running the squirrel experiment with 9-14 year olds at Brookfield Zoo summer campers, I was able to use a gamut of multiple intelligences to promote learning. The children used multiple intelligences: linguistic (handled new vocabulary such as predator, prey, dispersal, fear); bodily/kinesthetic (when they played a "tag" game to understand the effect of predation on fear and the squirrel's foraging behavior); logical (when counting hazelnuts left or taken, measuring seed dispersal distances, and writing numerical results on paper), spatial (when they made a map of the sampling area using a compass); naturalistic (when they walked in the woods as a group); interpersonal (when the discussed their perspective about foraging and fear with the group); intrapersonal (when they reflected on their own conclusions and what to do next); existential (when they discussed how did the results may relate to protection of endangered species or other subjects). I was proud when a couple of campers came the following day to tell me that they were running the experiment in their backyards, with hazelnuts and dental floss! They were learning, testing, and enjoying doing science. This was my biggest success! As a result, my stances have changed and have benefitted by this class (and the students are already benefitting from it!).

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