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Helping students explore the world of

Alison Perkins and Carol Brewer,

ABSTRACT:

Although insects and plants are major units in the elementary school curriculum, not all teachers have the tools to investigate this important ecosystem service, particularly at the lower elementary level. School reform efforts recommend incorporating inquiry to emphasize using knowledge, ideas, and processes. Constructivist theory suggests that free-choice education opportunities also may be important in science concept formation, especially when families provide encouragement. Therefore, we developed an inquiry and take-home story to engage families in their children's science learning. The inquiry, "What in the world do insects see?", was designed for 1st and 2nd grade students as an exploration of how insects see their world. The goal was to illustrate how our understanding of ecological relationships is affected by our perceptions. By examining the structure of insect eyes, students learned that insects may see the world very differently then they do. Students were introduced to insects as pollinators using ultraviolet photographs of flowers and observed flowers and pollinators outdoors. To complement this investigation, the inquiry was re-written as a story for families to read with their children. The story included activities from the classroom inquiry and encouraged families to explore their own backyards. Pre- and post-assessments indicated that the inquiry significantly increased student understanding that insect pollinators may see flowers quite differently than humans (chi square, $P < 0.02$), but students experiencing both the story and the inquiry gained a better appreciation of the nature of science than those experiencing either the inquiry or story alone (chi square, $Ps < 0.03$). This project was completed as part of the NSF GK-12 program at the University of Montana.

Introducing Insects

Ecologists, Educators, and Schools (ECOS) is a GK-12 fellowship program funded through NSF to partner graduate students with teachers and schools in and around Missoula, MT to enhance ecology education. Graduate Fellows develop and implement ecology-based inquiries with their partner teachers. Our ECOS team was based at the Lewis and Clark Elementary School and two multi-grade (1st and 2nd grade) class teachers (Mrs. M. and Mrs. S.).

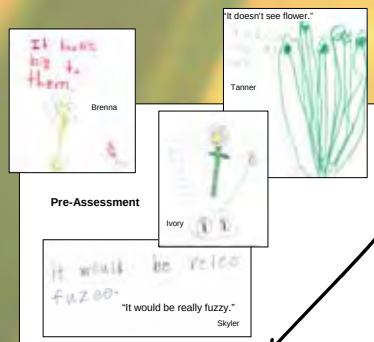
Insects were identified as a major curriculum unit for 1st grade and plants a major unit for 2nd grade by the Missoula County Public Schools Standards for Teaching Science (2005). Exploring the relationship between insect pollinators and plants seemed appropriate for these multi-grade classrooms. Therefore, we developed an inquiry about insect eyesight for early elementary students. The inquiry was designed to supplement the insect unit the school built around a commercial instruction kit (FOSS) focusing on insect life cycles. We designed the inquiry to foment student thinking about what scientists currently know about insect eyesight, what they can really know, and perhaps how the students, as scientists, might investigate eyesight. We focused specifically on insect pollinators.

The Story: Clio the Scientist

We developed a narrative to reflect the nature of scientific inquiry based on the insect inquiry. The story included all components of the inquiry presented in the classroom. In the story, a young girl already interested in insects begins to wonder what insects see. She turns to her family for help, and together they reason through how humans might study what insects see. The family members provide some information and encourage the young girl to question and find other information. Indeed, students were to go out and observe insect pollinators in their own backyards and draw and record their observations directly in their "book." The story provided an opportunity for parents to engage with their children in inquiry related to their child's formal science experiences.

Study Design

To test the impact of the narrative on student understanding, the ECOS team presented the inquiry alone to one ECOS teacher's class, the inquiry supplemented by the story to the other ECOS teacher's class, and we gave the story alone to a third teacher's class. This third teacher was an ECOS alumni and also taught multi-grade 1st and 2nd grades. She was teaching the insect curricula using the FOSS kit. We developed a simple assessment using drawings and Likert-type questions based on the teachers' assessment of what the students would be able to comprehend. Both current ECOS teachers approved the final questions.



Pre-Assessment

Classroom 1: Mrs. M.

Learning about Insect Eyes through Inquiry

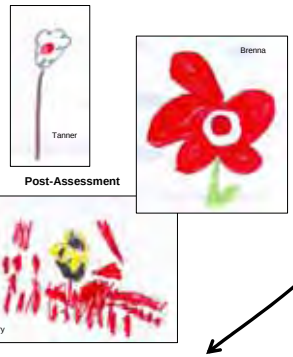
Assessment – student drawings

Pre-assessment:

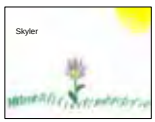
- Students most often drew multiple images of flowers or the faceted insect eye to represent the multiple images.
- One student believed that insects could only see in black and white, another that insects can't see plants or parts of the plant (i.e. the flowers), and another felt the image would be "fuzzy."
- Only one student recognized the size differential. Other drawings were straightforward flowers.
- Three simply did not know and drew nothing.

Post-assessment:

- 10 drawings reflected the ultra-violet photographs of flowers with dark centers and light outer edges.
- Three students drew multiple images of the flower in the post-assessment; all three had drawn multiple images in the pre-assessment as well.
- One of these, however, seemed to incorporate the different colors of flowers in the drawing as well as the multiple images.



Post-Assessment



Assessment – I agree, I don't know, I don't agree

Most students came into the experience with an understanding that insect eyes aren't the same as human eyes; we may not see things the same way, and our eyes aren't the same. Students had a better understanding of the differences after the inquiry.

Proportion of students that disagreed with the statements

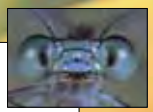
Statement	Percentage	n
Insects see flowers the same way I see flowers		
Pre-test	50%	14
Post-test	88%[a]	17
Insect eyes are just like human eyes		
Pre-test	77%	13
Post-test	94%[b]	17
The way I see the world is the way the world really is		
Pre-test	21%	14
Post-test	41%	17
Scientists know how insect eyes work		
Pre-test	14%	14
Post-test	12%	17

[a] $Z = -2.46$, $p = 0.01$
[b] $Z = -1.73$, $p = 0.08$

The statements "Insects see flowers the same way I see flowers" and "Insect eyes are just like human eyes" differed significantly between pre- and post-assessment for the inquiry classroom, and all changes moved toward the correct answer.

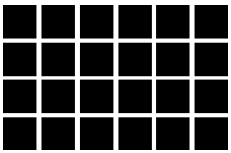
Few students recognized the nature of the scientific endeavor, namely that scientists are still trying to figure things out.

What in the World do Insects See?



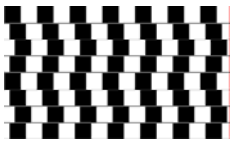
(1) Students were engaged in activities as part of an investigation to help them understand their own binocular vision; they pretended they were flies looking for cheese.

(2) Children examined basic optical illusions.



Do you see the gray ghosts?

Are the horizontal lines straight or bent?



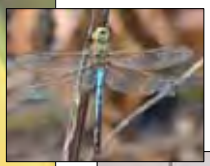
(3) We turned to insect pollinators and discussed factors that might influence plant pollinators. We explored the world of ultra-violet photographs of flowers, discussing where nectar was located and how insects might be able to find nectar if they could see with the ultra-violet portion of the color spectrum.

human

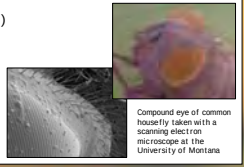
(4) We examined pinned insect pollinators and discussed what scientists did know about the structure of insect eyes using diagrams from textbooks. We focused the discussion on what and how insects might see, given what we knew about our own eyesight and how that might affect how we can know about insect (or dog or fish) eyesight.

insect

Photos courtesy of Bjørn Rørslett
http://www.naturfotograf.com



(5) We introduced the students to the structure of insect eyes using diagrams and scanning electron microscope (SEM) photographs and challenged them to explore their outdoor classroom, watch the insect pollinators, and make observations about insect eyes.



Compound eye of common housefly taken with a scanning electron microscope at the University of Montana

Acknowledgments

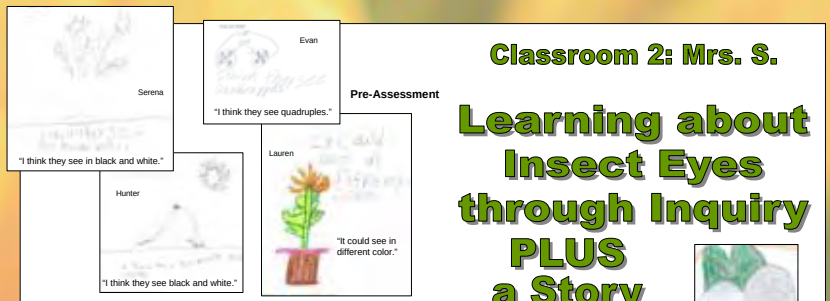
We especially would like to thank Kathy Dungan, Christy Meuer, and Elizabeth Sharkey, and all of their students for their thoughtful and fun-filled participation in this project. Nathan Gordon also was instrumental to implementing the inquiry and offered many helpful suggestions with the assessment. Thanks also to Diane Smith and Dave Oberbillig for helpful comments. This project was supported by the GK-12 Program of the National Science Foundation.

insect pollinators: The "eyes" have it

University of Montana, Missoula, MT 59812

Classroom 2: Mrs. S.

Learning about Insect Eyes through Inquiry PLUS a Story



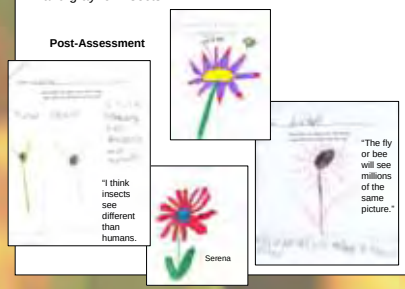
Assessment – student drawings

Pre-assessment:

- Only one student indicated multiple images (insects see four images, to be exact), but three students suggested insects could only see in black and white.
- Two students offered a different range of colors (visible light), and one suggested that insects could only see flowers (not stems).

Post-assessment:

- Flowers were consistently drawn with dark centers and contrasting outer petals (16 students), even though the plant they were given to draw had solid yellow flowers.
- The single student who had indicated multiple images in the pre-assessment also drew the flower as a contrasting dark center with light petals, but he added the insect would "see millions of the same picher [sp]."
- One student drew the flowers as colorful for humans and gray for insects.



Assessment – I agree, I don't know, I don't agree!

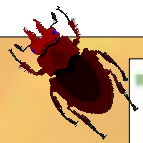
Only the combination of Inquiry + Story was effective for learning ideas about insect eyes and ideas related to the nature of the scientific process, that our brains process information we see and that science is an active process.

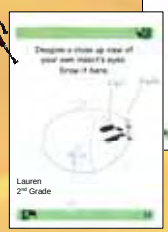
Proportion of students that disagreed with the statements

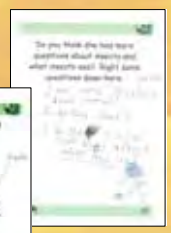
Statement	Percentage	n
Insects see flowers the same way I see flowers		
Pre-test	25	12
Post-test	100[a]	14
Insect eyes are just like human eyes		
Pre-test	77	13
Post-test	100[b]	15
The way I see the world is the way the world really is		
Pre-test	36	11
Post-test	80[c]	15
Scientists know how insect eyes work		
Pre-test	9	11
Post-test	93[d]	14

[a] $Z = -2.76$, $p = 0.01$
[b] $Z = -1.73$, $p = 0.08$
[c] $Z = -2.27$, $p = 0.02$
[d] $Z = -2.27$, $p = 0.02$

How can they see straight if their eyes are on the side?
Taylor

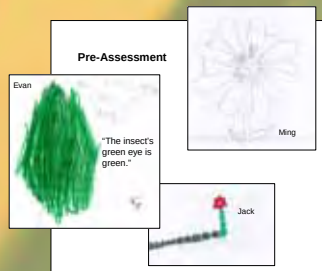






Classroom 3: Mrs. D.

Learning about Insect Eyes through Story Only



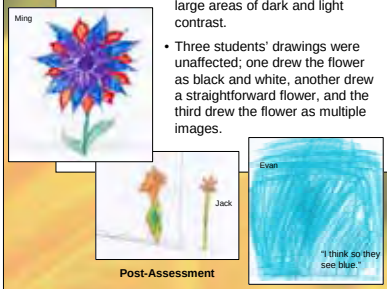
Assessment – student drawings

Pre-assessment:

- The majority drew flowers that were straightforward, but four incorporated some kind of multiple images of the flower or insect's eye.
- Other students were diverse in the way they approached color vision.
- One student believed insects could see through flowers, two argued for black and white, and two suggested that insects had only smell as a way of finding flowers.
- Two students drew the size disparity between insects and flowers.

Post-assessment:

- Nine students drew flowers with large areas of dark and light contrast.
- Three students' drawings were unaffected; one drew the flower as black and white, another drew a straightforward flower, and the third drew the flower as multiple images.



Assessment – I agree, I don't know, I don't agree

The story alone had a small effect on students' learning.

- Students' understanding of concepts showed no consistent difference with the story alone.
- Mrs. D. felt she had to keep reminding students to read the story and was not confident of her success.

Proportion of students that disagreed with the statements

Statement	Percentage	n
Insects see flowers the same way I see flowers		
Pre-test	63%	19
Post-test	82%	11
Insect eyes are just like human eyes		
Pre-test	79%	19
Post-test	91%	11
The way I see the world is the way the world really is		
Pre-test	11%	19
Post-test	55%	11
Scientists know how insect eyes work		
Pre-test	5%	19
Post-test	9%	11

Who discovered that insects have so many eyes?
Evan

Helping Students Explore the World of *Literacy*: The Eyes Have It

Inquiry oriented narratives may bridge the formal learning environment with the informal, bringing inquiry to home and family. Free-choice science educators recommend teachers encourage out-of-school participation in free-choice activities and home-centered activities because it adds to formal learning and develops students in different ways (Rutherford and Billig 1995, Zuzovsky and Tamir 1989, Resnick 1987). Results from Science PALs show that family involvement can be achieved with meaningful, time-efficient, and worthwhile take-home science activities incorporating literature (Shymansky et al. 2000).

- Inquiry alone does not necessarily enhance the understanding of the nature of science; explicit instruction and scaffolding is necessary (Rudolph 2005, Sandoval 2005, Schwartz et al. 2004, Yore 2004).
- Families clearly are important to student learning in both formal and informal learning environments. Constructing interesting interactive narratives from inquiries already developed with an approach to teaching the nature of science in the outdoors may be another way of engaging parents.

Learning Outcomes Varied Among Classrooms

- We used the differences in pre- and post-assessment scores for each student to test how treatments affected responses.
- Students experiencing the inquiry (both Inquiry Only and Inquiry + Story) changed their answers to the correct ones more often, or to a greater degree, than the story alone with respect to insect eyes.
- The largest treatment effect was evident regarding the nature of the scientific endeavor, i.e., getting students to realize that scientists don't know everything.

Tests for differences in the distribution of differences scores (the inverse of the post-assessment score minus pre-assessment score) for the three classrooms.

Question	Likelihood Ratio	df	P
Insects see flowers the same way I see flowers	10.917	6	0.09
Insect eyes are just like human eyes	12.983	6	0.04
The way I see the world is the way the world really is	8.025	8	0.43
Scientists know how insect eyes work	23.526	8	0.003

"There was a difference in the quality of the things they brought into class. It wasn't just something they found, it was more in-depth. They wanted to share what they understood about things. They noticed more relationships and transferred knowledge from different things they learned about insects to other areas, for example eye symmetry in sharks and insects. For 1st and 2nd graders, that's just really exciting when you see that."

- Mrs. S., teacher

Can insects see shapes? Can insects swim?
Serena

Informational Narrative Text:

- can help students develop skills that can be applied to both inquiry in science and reading for literacy (Casteel and Isom 1994);
- may engage students that identify themselves more as readers than as scientists, such as girls (Ford et al. 2006);
- can contribute to student learning in the early grades where these kinds of texts are scarce (see Duke 2000);
- may be even more valuable to low-SES school districts where informational texts are generally unavailable (Gerber et al. 2001, Duke 2000);
- can serve as opportunities for assessment that not only gauge student understanding but how well students are engaged at home.

Developing narratives from freely available inquiries, such as those provided by ECOS (**www.bioed.org/ECOS**) is a fairly easy, and straightforward process.