Using Insects to Promote Science Inquiry in Elementary Classrooms

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Abstract

The University of Nebraska-Lincoln and Nebraska public schools created Bugs in the Classroom, a professional development initiative with the goal of empowering teachers to use insects in science inquiry instruction in elementary classrooms. The initiative included workshops for elementary educators on science inquiry and teaching with insects. This paper includes a description of the workshop as well as an evaluation of the impact of the workshop on participating teachers' knowledge of scientific inquiry, entomology knowledge, and inquiry practice. Also included are recommendations for similar professional development activities.

Introduction

Science education research has demonstrated that most students learn best through experiencing the nature or processes of science and by connecting new information to their existing knowledge (Bransford et al., 1999; Montague and Mussen, 1998; Driver et al., 1985; Driver et al., 1994). The National Science Education Standards support transforming science education to engage students in active learning through inquiry-based teaching and learning, and to provide students with opportunities to personally construct their own knowledge by asking questions, developing testable hypotheses, collecting and analyzing data, interpreting and communicating results of their work (National Research Council, 1996a). Education researchers have demonstrated that inquiry-based teaching and learning can improve student attitudes towards science, enhance their performance in science, and promote scientific literacy (Haury, 1993; Lindberg, 1990; Mattheis and Nakayama, 1988; Rakow, 1986).

Professional development, which is a component of the National Science Education Standards (National Research Council, 1996a), is one avenue for empowering teachers to use science inquiry. Among the recommendations made by the National Science Education Standards (National Research Council, 1996a) is to provide professional development opportunities for science teachers led by research scientists. The benefits of partnering science teachers with research scientists include invaluable hands-on research experience, opportunities to develop critical thinking and problem-solving skills, and long-term collaborations between science teachers and scientists (National Research Council, 1996b). Scientists as content experts also build teachers' knowledge of science, and through modeling of inquiry, teacher confidence (Loucks-Horsley et al., 2003).

Recognizing the need for professional development opportunities that promote and improve inquiry instruction in the science classroom, the Department of Entomology at the University of Nebraska-Lincoln and Nebraska public schools created the Bugs in the Classroom initiative. The Bugs in the Classroom initiative included a series of workshops for elementary education teachers to stimulate their interest in science and to engage them in inquiry-based learning experiences. The primary goal of the initiative was to improve participating teachers' science process understanding and their ability to teach science using an inquiry-based teaching approach. While the focus of Bugs in the Classroom was on improving inquiry-based pedagogy, emphasis was also placed on content knowledge. Content instruction is an important component of reform strategies in science education and effective professional development programs (Kennedy, 1998; Supovitz and Turner, 2000). Further, Borko (2004, p.5) states, "Professional development that includes an explicit focus on both knowledge and the process of science can help teachers develop these powerful understandings." Therefore, a goal of the workshop was improving knowledge of key concepts related to science inquiry and insect biology instruction.

Project coordinators used insects not only because of their area of expertise but because children are fascinated by insects, they are excellent model organisms for teaching many biological processes common to all living organisms, and they have a huge impact on human society (Center for

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Insect Science, 1993). Insect life cycles, behaviors, adaptability, and evolutionary success provide unlimited possibilities for students to generate and test hypotheses (Matthews et al., 1996; Matthews et al., 1997). Insects also have a huge impact on food production, an especially relevant topic in Nebraska where the economy is dominated by agriculture.

The Workshop

Three workshops were offered to both urban and rural school districts. A total of 82 elementary school teachers with a mean of seven years teaching experience participated in the workshop. While 82% of teachers stated that they had used inquiry instruction in their science teaching prior to the workshop, experience teaching science through the inquiry process was not a prerequisite for participation.

The workshop's goals were to improve teachers' knowledge of basic entomological concepts, science inquiry process understanding, and inquiry teaching practices. The outcome of the workshop was having teachers implement science inquiry investigations (prepared by the *Bugs in the Classroom* coordinators) in their classrooms. These inquiry investigations utilized insects as the teaching tool with exercises ranging from physiological and behavior studies to food preference inquiries. A complete list of the lessons can be found at http://entomology.unl.edu/k12/index.shtml.

Day one of the two-day workshops focused on science inquiry and entomology concept acquisition and participants working with live arthropods. The mode of instruction for day one was a series of lectures, hands-on opportunities with live arthropods, and structured inquiry investigations to introduce key insect biology and science inquiry concepts. Participants spent the second day conducting a series of insect-based inquiry investigations, matching the inquiry investigations with the National Science Standards, and developing their own innovative inquiry investigations. Engaging teachers in inquiry teaching was an important component of the workshop. Practice builds teacher confidence in incorporating new teaching techniques and is a critical component of quality professional development (Klein, 2001; Loucks-Horsley et al., 2003). Throughout the two-day workshop, there were also opportunities for participants to ask the coordinators questions related to the inquiry teaching approach and the insects used in the inquiry investigations.

After attending the workshop, project coordinators encouraged participating teachers to teach critical thinking and problem solving skills to their students by embedding biological content involving insects in an inquiry-based pedagogy. Each participating teacher received a teaching kit containing all the materials needed to conduct the insect-based inquiries they engaged in during the workshop. They were also encouraged to contact the coordinators if they had questions regarding insects, the lessons, and science inquiry instruction.

In addition to basic demographic data, coordinators were also interested in determining the impact of the *Bugs in the Classroom* on participants and their teaching. The evaluation instrument, created by an independent evaluator, focused on changes in participating teachers' understanding of insect biology and science inquiry. This evaluation also looked at self-reported changes in teacher's use of science inquiry in the classroom. Finally, the evaluation sought to determine the long-term impact on science inquiry application in the classroom. In particular, did teachers incorporate more science inquiry into their curriculum, and was there evidence available to document changes in their instruction.

Materials and Methods

Project coordinators conducted pre- and post-workshop evaluations to measure workshop-related changes in teacher knowledge of insect biology and their understanding of application of science inquiry teaching approaches. The pre-workshop evaluation (administered at the beginning of the workshop) contained questions on entomological concepts and science process (inquiry) understanding (see Table 1). Insect biology questions were selected based on basic entomology concepts and knowledge needed to conduct the project inquiry investigations. Coordinators selected science process understanding questions in a similar manner, but they also took into account the State and National Science Education Standards for inquiry by including questions covering basic principles of science inquiry understanding. The pre-workshop evaluation also included self-assessment items to measure participants' insect biology and science inquiry understanding in relation to their perceived ability to incorporate science

Table 1. Entomology and Science Process Questions

Entomology understanding
Which of the following diagrams is an insect? (4 diagrams including 3 non-insect arthropods).
List the names of three insect orders (scientific or non-scientific names).
List 3 different forms or types of insect communication.
Name three social insect groups.
Science inquiry understanding
List the six steps for conducting a scientific inquiry.
Which of the following is a testable hypothesis?
Which of the following is the best example of a scientific inquiry?

Table 2. Teacher Confidence in their Knowledge Questions
Pre & Post Workshop
My current level of insect biology is such that I can effectively use insects in science inquiry lessons.
My current level of science inquiry understanding is such that I can effectively incorporate science inquiry into my classroom.

inquiry investigations in the classroom (see Table 2). These questions measure change in confidence, before and after the workshop, in using insects and the inquiry methodology in teaching. Finally, the evaluation included a question asking participants to list the number of inquiry lessons instructed in the semester before the workshop (see Table 3).

The post-workshop evaluation (administered at the conclusion of the workshop) contained matching questions from the pre-workshop evaluation for measuring the impact of the workshop on participants' entomology and science process understanding. Also included was a question asking participants if their definition of inquiry changed as a result of attending the workshop, and a question asking if they planned to incorporate more insect-based inquiry lessons in their classrooms as a result of the workshop (see Table 3).

A six-month follow-up survey was conducted to determine the long-term impact of *Bugs in the Classroom*. Coordinators administered the survey via mail following teachers' participation in the workshop. The intent was to measure the impact of *Bugs in the Classroom* after the inquiry investigations were used in their classrooms. The survey included questions on the impact of the workshop on participants' instruction and practice of science inquiry teaching in the classroom (see Table 3). The survey also included a single open-ended question to gain additional insight regarding participants' workshop experience and its impact on their teaching.

All questions were checked for content validity with a trial-group of graduate students and faculty members in the Department of Entomology. Chronbach's alpha coefficient was calculated to determine the internal reliability of the evaluation instrument. The internal reliability for the evaluation instrument was $\alpha = 0.74$. The test-retest reliability was calculated using a Pearson's correlation coefficient. The test-retest reliability was $r = 0.40$.

McNemar Tests were used to determine the differences between pre-and-post-workshop responses to content knowledge. Wilcoxon sign-ranks test was employed for questions regarding self-assessment ratings, with exceptions to use as noted in the results.

Prior to initiating the study, the survey instrument, methodology, and informed consent form were approved by the University of Nebraska Institutional Review Board. The informed consent form contained information about the study and the workshop participants' rights to be excluded from the study. Informed consent was presented to participants at the pre, post, and six-month evaluations.

Results

Only participants that attended both days of the workshop, taught science as one of their subjects were included in analysis (N= 59). For the six-month follow-up survey, 48 participating teachers returned their surveys. An alpha level of 0.05 was used for all statistical tests.

Entomology knowledge

There was no significant change from pre- to post-test in participants' ability to identify an insect (McNemar's, P=1.00). Most participants (89.5%) understood the basic characteristics of an insect and could identify an insect from non-insect arthropods. To evaluate participants' understanding of key insect biology concepts, we compared pre- and post-workshop insect biology responses. For each of the insect biology questions there was a significant change in the number of questions answered correctly (see Table 4).

Teachers were also asked to assess their insect biology and science inquiry knowledge in relation to their ability to teach science inquiry lessons with insects, before and after the workshop. These questions were used as an indicator of changes in participating teachers' confidence. Results for these

Table 3. Science Inquiry Practice Questions
Pre-Workshop
During the previous semester (2 school quarters), what is the number of lessons or activities you instructed that used insects for science inquiry?
Post-workshop evaluation
As the result of the workshop I plan to incorporate more science inquiry lessons using insects into my curriculum.
6-month survey
As the result of the workshop I have incorporated more science inquiry lesson using insects into my curriculum.
As a result of the workshop I have used inquiry in my non-life science curriculum.
During the previous semester (2 school quarters), what is the number of lessons or activities your instructed that used insects for science inquiry?

questions are summarized in Table 5. For both questions there was a significant positive shift in the level of agreement with the self-assessment questions from the pre- to post-workshop sessions.

Table 4. Insect Biology Understanding Change Pre to Post-Workshop

	Pre-workshop		Post-workshop			
	M	*SD*	*M*	*SD*	*z*	*p*
Three insect orders	0.90	1.27	2.05	1.22	4.86	0.01**
Three ways insects communicate	1.71	1.05	2.56	0.53	4.20	0.01**
Three insect social groups	2.17	1.10	2.92	0.43	4.17	0.01**

NS, *,**, ***, Nonsignificant or significant at *P=0.05, 0.01, or 0.001*, respectively using Wilcoxon signed-ranks test

Table 5. Self-Assessment of Understanding: Level of Agreement to Confidence Statements

	Pre-workshop		Post-workshop			
	M	*SD*	*M*	*SD*	*z*	*P*
My current level of insect biology understanding is such that I can effectively incorporate science inquiry using insects into my instruction.	2.93	.96	4.08	.77	-5.145	0.01**
My current level of science inquiry understanding is such that I can effectively incorporate science inquiry into my classroom.	3.37	.95	4.27	.72	-4.960	0.01**

Likert scale (1 = strongly disagree, 5= strongly agree).
NS, *,**, ***, Nonsignificant or significant at *P=0.05, 0.01, or 0.001*, respectively using Wilcoxon signed-ranks test

Science inquiry knowledge

For the six steps of the science inquiry process knowledge question, there was a significant difference, P = 0.001*** z=6.00, in the number of correctly identified steps in the science inquiry process from the pre-workshop evaluation (M=3.25, SD=1.65) to the post-workshop evaluation (M=5.51, SD=0.70).

There was a significant positive change in the number of participants that correctly identified a testable hypothesis. However, there was no statistically significant change in the number of participants that correctly identified the best example of a science inquiry investigation (see Table 6). Teachers were also asked, “As a result of the workshop my definition of science inquiry has changed.” In total, 69.5% of teachers answered yes, 30.5% answered no.

Science inquiry practice

There was no significant difference (t=1.81, P=0.24) in the number of science inquiry investigations reported taught pre-workshop (M=3.38, SD=5.44) and six months following the workshop (M=4.69, SD=5.59). Teachers were also asked to determine if they had used inquiry teaching in their non-life science courses. Thirty-eight participants responded to this question, 92.1% answered yes, 7.9% answered no. This indicates that a large proportion of the participants also utilized the inquiry approach in their non-life science teaching.

Table 6. Change in Science Inquiry Knowledge Pre- to Post-Workshop

	W1 W2	R1 W2	R1 R2	W1 R2	c²	P
Testable Hypothesis	6.77%	0%	44.06%	49.15%	27.03	0.01**
Best Science Inquiry Example	11.86%	6.78%	72.88%	8.47%	---	1.00NS

NS, *,**, ***, Nonsignificant or significant at *P=0.05, 0.01, or 0.001*, respectively using McNemar Tests; *W* = wrong, *R* = right

The open-ended question included a variety of data regarding participants' workshop experience and their implementation of the project. Nineteen participants responded to this question and their written responses are categorized as follows.

Three teachers stated that their knowledge of inquiry increased because of the workshop. *“I have dramatically increased the amount of science inquiry in my 2nd grade classroom because I have a better understanding of how to conduct the project properly. I was never a fan of insects and now have two African millipedes, three Madagascar hissing cockroaches, and multitude of offspring.”*

“This workshop has enabled me to see how the science inquiry process helps students better understand how to solve problems in a more systematic way.”

“It has made me much more aware of the extent I can use the scientific method and inquiry with my kindergarten students. As any teacher knows, you can never have too many hands-on activities!”

Three teachers mentioned that the workshop increased their confidence in teaching science and/or use of inquiry in the classroom.

“Of all the subjects I teach, science in the past has been my least favorite subject to teach. However, this workshop has given me confidence to bring science alive to my students.”

“The biggest value was having two people who are entomologists. Both gave me lots of resources and materials to take back and use right away. I did not have any experience with entomology. So now, I have [added] confidence.”

“I feel confidence in using organisms in my classroom now.”

Five teachers commented on a change in their use of inquiry in the classroom.

"I have dramatically increased the amount of science inquiry in my 2nd grade classroom because I have a better understanding of how to conduct inquiry properly."

"It provided many more activities and inquiries for the elementary classroom. I have always taught science based on the scientific method and I am always looking for new ideas. I have changed my teaching to allow for more student questioning."

"I have incorporated more science inquiry into science activities other than insects."

"The science inquiry approach was built upon to a further step than I had been doing in the past."

"The workshop was valuable because I performed many of the inquiries so I could see which I wanted to use and be ready to incorporate right away. I now try to look at my unit plans and see if I can rearrange activities as inquiries and use them to introduce topics instead of reading to them to introduce an activity."

Three teachers commented on parent or school community involvement in the project.

"I have parents requesting to have a baby roach at home so that their children can experience their life-cycle first-hand. Wow!"

"The students are enjoying the cockroach and taking them home on the weekends. Can't say the parents have gotten the interest there but we will get there."

"A group of teachers at our schools who attended the workshop are trying to put together and insect night for families to attend at our school."

Some teachers also provided comments on the challenges of incorporating science inquiry into their classroom.

"Unfortunately, due to the current emphasis on meeting the state-science standards and objectives (as measured by the CR tests) we as teachers are having to teach/exam a huge amount of materials into a fairly short time period, thus leaving little to no time for inquiry based activities. Another "problem" is that only one of our quarters deal with the life science realm. I have not made enough connections to see how I could do inquiry-based activities…"

"Good workshop but our curriculum is being directed to doing CRTs and teaching to the test more than inquiry. Inquiry is great, but the time it usually takes makes it hard to get all the topics in we are supposed to cover."

"It was a very memorable workshop. I just have trouble coming up with the time to do much. Either it's the wrong time of the year... Also with state testing it is hard to find time to work inquiry in."

Others provided insight as to why they did not incorporate the inquiries into their classroom.

"I usually do more with insects during the second semester in the spring so I have not had the chance to incorporate many of the activities we did this summer."

"It has at least given me a better understanding of what inquiry looks like so I can modify my existing lessons or create new ones. I do plan on using some from the workshop in the spring semester – more science in the spring."

Conclusions and Summary

Based on the evaluation summaries, it is evident that the workshops successfully stimulated interest in science and engaged teachers and their students in inquiry-based learning experiences. As a result of the workshops, teachers not only improved their understanding of inquiry science, but also their knowledge of insect biology. Teachers also reported that their confidence in teaching with insects improved as a result of the workshop. Based on teacher feedback we believe this is largely due to the hands-on nature of the workshops and the information provided about rearing and obtaining insects.

Teacher's knowledge and understanding of inquiry-based pedagogy also improved as a result of the workshop. Participating teachers were able to identify more essential steps of the inquiry process after completing the workshop. Teachers also improved in their ability to identify a testable hypothesis post workshop. However, teachers did not show a significant increase in their ability to identify the best example of an inquiry investigation. This is due to a high percentage (72.9%) correctly identifying testable hypotheses before the workshop.

As a measure of confidence, teachers reported that their knowledge of inquiry increased, and as a result, they felt that they could better incorporate inquiry investigations in their classrooms. On a related question, a majority of participants stated that they planned to include more science inquiry lessons using insects in to their classrooms as a result of the workshop. However, the six-month follow-up survey did not show a significant self-reported increase in the number of inquiry investigations than prior to the workshop. One explanation is that many teachers did not incorporate inquiry in their classrooms before administration of the six-month follow-up survey. The six-month follow-up survey was administered at the end of the fall semester (second quarter) following *Bugs in the Classroom* workshop. Three teachers reported that they had yet to incorporate the inquiry investigations into their classrooms and would do so in the spring semester. These teachers simply did not incorporate inquiry investigations into their classrooms yet. Other teachers mentioned constraints that prevented them from incorporating inquiry lessons in their classrooms. Time and policy constraints are one of the many barriers in incorporating reform curriculum (National Research Council, 1996; National Science Foundation, 1998). These constraints, especially the belief by some participating teachers that the *Bugs in the Classrooms* inquiry investigations would not facilitate student learning of key concepts assessed by the local criterion referenced tests (referred to as C.R.T.s by participants). While the inquiry investigations were developed to teach core concepts of the state's department of education science standards, for some teachers there was a belief that the *Bugs in the Classroom* inquiries deviated too far from their locally- approved curriculum. Future professional development endeavors should involve collaborations between teachers, school administrators, districts, and state level groups to address curriculum and time constraints. Conversations between these groups may help address concerns of how curriculum from initiatives like *Bugs in the Classroom*, while not a part of the approved curriculum, can be used to address state and national science education standards.

While there was no statistically significant increase in the number of inquiry lessons, evidence from the evaluations supports that inquiry instruction did change in some classrooms. Several teachers mentioned an increase in the number of steps in the inquiry process used in their instruction. This may be a result of the workshop changing teachers' definition of inquiry and that the prepared inquiries as a part of *Bugs in the Classroom* engaged students and teachers in all steps of an inquiry investigation. Another change in inquiry instruction use was that a majority of teachers reported that they also used inquiry in their non-life science classrooms. While this was not a primary goal of *Bugs in the Classroom*, it shows that teaching strategies covered in the workshop had an impact on other subject areas. As this was an unexpected result, we did not inquire further as to which subjects inquiry teaching methods were also used in or to what extent. However, based on participants' feedback on the six-month evaluation, it is possible that they recognized the benefit of inquiry teaching methods in other subject areas. Asking additional questions would offer some insight into the “richness” of the inquiry used in other subject areas.

Finally, teachers commented on parent and school community interest in the *Bugs in the Classroom* curriculum. This supports the positive impact of this project on participating school communities and parents' interest in science instruction. Community support is an important component of reforming science teaching and curriculum (National Science Foundation, 1998). Projects like *Bugs in the Classroom* can serve as a foundation for teachers, school administrators, and parents working together to develop and support expanded science instruction reform initiatives.

Bugs in the Classroom clearly shows that readily available and low cost organisms, especially insects, can be an effective vehicle for inquiry instruction. More importantly the results from *Bugs in the Classroom* demonstrate that professional development led by research scientists can impact elementary teachers' knowledge of science processes and science as inquiry teaching practices. In addition to fulfilling the outreach mission of a land grant institution, the positive outcomes of having research scientists contribute to the professional development of pre- and in-service teachers were evident in feedback from the participants. Land grant institution scientists are experts in the husbandry and location of low-cost resources, and they are daily practitioners of scientific inquiry. By precept and example, they can provide elementary educators valuable insights on teaching science content and process.

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