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The role of entomology in environmental and science education: Comparing outreach methods for their impact on student and teacher content knowledge and motivation

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THE ROLE OF ENTOMOLOGY IN ENVIRONMENTAL AND SCIENCE EDUCATION: COMPARING OUTREACH METHODS FOR THEIR IMPACT ON STUDENT AND TEACHER CONTENT KNOWLEDGE AND MOTIVATION

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ABSTRACT

Weeks, Faith J. Ph.D., Purdue University, May 2015. The Role of Entomology in Environmental and Science Education: Comparing Outreach Methods for their Impact on Student and Teacher Content Knowledge and Motivation. Major Professor: Christian Oseto.

Outreach programming can be an important way for local students and teachers to be exposed to new fields while enhancing classroom learning. University-based outreach programs are offered throughout the country, including most entomology departments as few individuals learn about insects in school and these programs can be excellent sources of entomological education, as well as models to teach environmental and science education. Each department utilizes different instructional delivery methods for teaching about insects, which may impact the way in which students and teachers understand the insect concepts presented. To determine the impact of using entomology to enhance science and environmental education, this study used a series of university-based entomology outreach programs to compare three of the most common delivery methods for their effect on teacher and student content knowledge and motivation, specifically student interest in entomology and teacher self-efficacy. Twenty fifth grade classrooms were assessed over the course of one school year. The results show that teacher knowledge significantly increased when teachers were unfamiliar with the content and

when trained by an expert, and teacher self-efficacy did not decrease when asked about teaching with insects. For students, content knowledge increased for each lesson regardless of treatment, suggesting that outreach program providers should focus on working with local schools to integrate their field into the classroom through the delivery methods best suited to the needs of the university, teachers, and students. The lessons also had an impact on student interest in science and environmental education, with an overall finding that student interest increases when using insects in the classroom.

CHAPTER 1. INTRODUCTION

1.1 Introduction

Insects are the most abundant group of animals on the planet, comprising 81% of all animal species on the planet and with more than 925,000 described insect species (Grimaldi & Engel, 2005; Samways, 1993). Insects are a group of dominant organisms (Arnett, 1976; Tipton, 1976), and have successfully colonized all habitable environments through their adaptability and diversity (Creager, 1976; Fischang, 1976). Invertebrates play vital roles in the environment, enhancing the stability of ecosystems (Kellert, 1993), and engaging in relationships with other organisms that allow other species to survive (Looy, Dunkel, & Wood, 2014). These contributions by insects are often difficult to identify, as "the diverse and pervasive ecological roles of invertebrates are sometimes subtle, generally little understood, and often difficult to value economically" (Van Hook, 1994, p. 46). Because of the critical role of insects, the public must understand the value of diversity among organisms, including those that are considered less attractive or disgusting (Kellert, 1996). This interaction of insects with other organisms, including humans, impacts our lives and serves as an excellent tool for teaching the life sciences (Fischang, 1976).

Regardless of their immense importance and value, insects are often disregarded due to their strange appearances and behaviors. “Due to their environment, millions are not in contact with plants and animals as much as they should be…As a result they acquire many little fears and undesirable attitudes toward living things long before they have a chance to find out for themselves” (Woolever, 1953, p. 121). Without personal experiences, there is no connection with, and therefore no interest in, preserving insects or endangered species because “concern for the natural world is shaped through social learning, and that is shaped by opportunities for direct contact with nature” (Chawla, 1988, p. 26). Due to this negative perception, insects are often not included in school curricula. Matthews, Flage, and Matthews (1997) found that most teachers do not include insects in the curriculum because they have not overcome their own fears of these animals being disgusting and dirty. Often students are not provided with opportunities to develop more positive attitudes in their classroom due to a lack of information and direct contact with insect species, which is connected to their teacher’s fears and misunderstandings about insects (Chawla, 1988; Gray, 1976; Kahn & Friedman, 1995; Randler, Hummel, & Wüst-Ackermann, 2013; Shepardson, 2002; Simmons, 1994).

Schools can use insects in a variety of ways, especially in keeping them as learning tools in the classroom and using them as models to illustrate biological concepts. Raising live insects in the classroom benefits both students and teachers by giving them the opportunity to observe insect behavior, learn about their unique lifecycles, and ask questions inspired through their interactions with the specimens (Danoff-Burg, 2002). Invertebrates are inexpensive, are easily maintained due to their small size, have simple nutritional needs, and exhibit short lifecycles (Creager, 1976; Gray, 1976; Iliff, 1981;

Matthews et al., 1997). Insects should be a part of the classroom, more than just as an expendable resource (Arnett, 1976; Ball, 1998) as an insect's entire lifecycle can be observed in a single school year, and many insects can be found locally, even in urban areas (Gray, 1976). Invertebrates are especially great specimens for use in laboratory activities, as students can conduct experiments with few restrictions (Creager, 1976; Gentz, 2007; Miller, 2004). The use of living organisms in the classroom has been found to lead to a deeper understanding of their behavior and external characteristics (Hummel & Randler, 2012), as well as acting as a tool to engage students in developing their science skills (Bergman, 2008). Insects are also excellent models, allowing students to observe biological processes firsthand and making exceptional model organisms in research projects (Creager, 1976; Golick & Heng-Moss, 2013; Miller, 2004; Richardson & Hari, 2008). The National Science Education Standards recommend insects as an ideal group to study function and structure (National Research Council, 1996), probably due in part to their ability to demonstrate the basic attributes of life in addition to those specific to insects (Sauer, 1976).

Despite the value insects have in both the environment and the classroom, these animals are continuously avoided when creating new school curricula (Wagler & Wagler, 2013). One way in which to give teachers and students an interactive, hands-on experience with insects is through entomology outreach, as numerous studies have found that interacting with and learning more about invertebrates can help reduce fear and disgust of these animals (Pitt & Shockley, 2014; Randler, Hummel, & Prokop, 2012; Randler et al., 2013). In 1989, the Entomological Society of America (ESA) began an outreach program to encourage the use of insects in teaching a variety of subjects, as well as provide teachers with contacts of entomologists willing to help them utilize insects in the classroom (Van Hook, 1994). Since then, entomologists have been encouraged to share their expertise and passion for insects with the public, especially young children, and to help them understand the need for conservation for this important group of animals (Kleintjes, 1996; Oseto, 1991). These outreach programs can increase the understanding of entomology content and collecting/maintenance techniques (Robinette & Noblet, 2009), as well as improve public relations with entomology departments, promote appreciation for insects, and potentially recruit students into the field (Frazier, 2002; Pitt & Shockley, 2014).

The field of entomology outreach is still rather small, resulting in only a few published research findings that demonstrate the worth of this area of study. Entomology outreach, however, can be situated in the larger field of entomology education, which offers more published articles about teaching about insects and other arthropods in a variety of educational settings. Some research related to entomology education is actually using insects and entomological concepts to teach about other subjects, such as science and mathematics. Studying the relationship between the three fields of entomology outreach, entomology education, and education with entomology, is an important way to learn more about these fields and determine how to distinguish them from one another. These three fields, however, do not represent the only entomology education offered to the public. Many other programs provide valuable methods to teach with insects, including extension programs, 4-H, and FFA, but this review will focus on programs with connections to more formal education and exhibits in public areas, such as museums and nature centers.

1.2 Entomology Outreach

From the few found published research articles in entomology outreach, there seem to be three key themes: exhibit evaluations; methods to increase awareness of insects; and attitudinal changes towards insects. Museum and zoo exhibits can be helpful to engage and educate the public about insects and other arthropods, although these types of entomology outreach are often not evaluated for their impact. Since 1996, an annual exhibit called Yebo Gogga has been held in the Johannesburg Zoo of South Africa. This exhibit changes yearly based on a random participant evaluation form, and the results of these evaluations were published by researchers Crump, Byrne, and Croucamp (2000). The evaluation form asks participants 12 questions, including favorite sections of the exhibit, the quality of posters and labels, and if the amount of information provided by presenters was adequate. This research found that 95% of responders labeled the displays as good, 71% found the exhibit to be crowded, and 72% of responders felt that they "learned a lot" (p. 15). Overall, the authors state that they believe their surveys have shown that Yebo Gogga is a successful insect and arthropod exhibit, and that this feedback allows them to meet the needs of the public, including exhibit displays, educational offerings, and location requirements. This study demonstrates the importance of exhibits in entomology outreach, as well as how even basic evaluations can help increase participant knowledge of insects and other arthropods, as well as how outreach educators can best tailor their efforts to meet the needs of the public.

Most entomology outreach educators would state that increasing public awareness of the insects around them is an important goal for this field, and there are many different methods to reach this goal. McCullough (2013) and her colleagues studied if digital macrophotography of insects taken by the public would impact their awareness of insects in natural settings than if the participants did not take any digital photographs. Specific species of butterflies, bees, and wasps were counted at six sites over a 13 week period by comparing samples taken by sweeping nets with pictures taken with digital cameras. McCullough (2013) found that digital macrophotography helped participants see and capture more insect biodiversity than when actual specimens were collected. Analysis of site differences found no significant differences between the six locations, but there was, on average, a higher proportion of species recorded with digital cameras. All photos in this study were also placed into a digital collection for future educational use. This research demonstrates not only the effectiveness of using digital macrophotography in raising awareness of insects in natural habitats, but also shows that there are alternate ways to increase this awareness. More research is needed, however, to show other effective entomology outreach methods to meet this important goal.

Part of the problem in educational outreach is that insects and other arthropods are often considered disgusting or dirty, and the attitudes of the public can be difficult to change. A research study in 2006 tested to see if educational bug banquets would change participant's negative attitudes towards insects and other invertebrates (Looy & Wood, 2006). Questionnaires were given before and after the bug banquet for the experimental group, which consisted of an educational lecture about invertebrates and about people eating them, then participants were served different foods that included insects, such as roasted crickets. The control group answered the questionnaire, but did not participate in the bug banquet. The results suggest that that there is no clear connection between bug banquets and changes in participant attitudes towards invertebrates. An analysis of the data revealed that reactions to eating insects, however, were strong for both ends of the spectrum; either the participants were interested or disgusted by the idea of consuming invertebrates. This research suggests that one time presentations about particular insect topics may not drastically change participant attitudes, but additional research is needed to generalize these results to other entomology outreach topics. Overall, entomology outreach is a field with limited research findings, but these three studies suggest that entomology outreach can make a difference, and that more published research results are necessary to help this field achieve its many goals for teaching with and about insects.

Entomology outreach also offers numerous types of smaller educational activities focused on insects and other arthropods. Many of these outreach programs have published descriptions of their activities to share with the public, including overviews of specific programs and ways that entomology outreach offerings could be improved. These published articles often lack research about their effectiveness, but can still contribute to the field by showing all the possibilities to educate about insects. These articles can be placed into two categories based on the objectives: those that discuss specific entomological programs and those that write about potential outreach activities with insects. Insect outreach organizations that offer specific programs to the public range greatly in their goals and methods to increase knowledge of entomology. An article highlighting the role of insects in Taiwanese culture, for instance, wrote about two insectaria that offer educational entomology programs and exhibits focused on insects in the country, as well as tours and summer camps (Yang, 2008). The College of Agricultural Sciences and The Pennsylvania State University also offered a Bug Camp for Kids because of their mission of public education and outreach and the entomology faculty wanting an opportunity for children to learn more about science and insects. This camp offered elementary aged children daily insect activities, including field collections and laboratory investigations with a heavy emphasis on observations and student generated questions about entomology (Boardman, Zembal-Saul, Frazier, Appel, & Weiss, 1999). Student questions also drove the winter entomology outreach offerings at the Western Upper Peninsula Center for Science, Mathematics, and Environmental Education in Michigan. This center offered winter field trips to explore insects in their overwintering sites and allowed the program content to partially be led by student curiosity and observations in the field after discussions of insect life cycles and insect identification counts for later data analysis (Schmidt, Chadde, & Buenzli, 2003). Other published articles do not share established educational offerings, but rather suggest activities that promote entomology and entomology outreach. Rillo (1971) wrote an article that provides educators with an overview of entomology and insect anatomy, and then offered methods and materials that can be used in outreach settings to teach these insect topics. Potential field trips are also suggested, including night excursions to hear insect sounds and collecting stream-dwelling invertebrates. Entomology outreach lesson objectives, vocabulary, activities, and even evaluation questions were provided by the author to stimulate learning about insects and an interest in the field. Other journal articles promote entomology outreach focused on a specific group of insects, such as seen in a 2012 article about the use of butterflies in the world. Part of this article offers educational reasons to include the study of butterflies as a way to enhance entomology education (Boppre & Vane-Wright, 2012). The authors write that engaging in effective environmental education that teaches about butterfly biology and their place in this world is important to not only teach about the importance of insects but of habitat conservation and appreciating other organisms. Educational kits that teach about butterfly lifecycles, habitats, and feeding needs are also discussed as an effective way to teach about these animals and metamorphosis. These two articles (Boppre & Vane-Wright, 2012; Rillo, 1971) do not concentrate on certain programs, but rather offer suggestions for teaching about entomology in outreach settings, but they, in addition to those that do discuss specific educational programs, contribute to entomology outreach by sharing their methods for teaching about and with insects and promoting insect education in formal and informal educational settings.

1.3 Entomology Education

Entomology education is a broader field, with more published works about different types of insect education programs than entomology outreach. A review of some of entomology education literature reveals three main themes: education about specific insects; methods to study insects; and research in entomology education. Many of the published articles in entomology education focus on teaching about specific insects or groups of insects, and their writings share the programs and activities that have been created. Over half of these articles are about insects that can be easily kept in classrooms, and often the authors share rearing methods to prolong their use in insect lessons (Marsteller, 1970; Matthews & Matthews, 2012; Palopoli, 1998; Wagler, 2010; Wagler & Moseley, 2005). Specific activities, including necessary materials and step-by-step directions, as well as tips for educators to engage students in the topic and the live specimens are provided. For instance, Wagler and Moseley (2005) wrote extensively about the Madagascar hissing cockroach and their specific habitat needs to be kept in classrooms, including temperature and diet. After sharing how to create a cockroach habitat, the authors offer over ten basic activities about these insects, ranging from simple observations to experiments in running speeds and territorial behaviors in male cockroaches. Throughout these published works, the authors emphasize the ease in keeping different insects in classrooms and how learning about their lifecycles and habits can increase student interest in insects, as well as science overall. Other publications, centered on specific insects, share previously conducted entomology education programs, their activities, and general observations about the success of the program (Gentz, 2007; Golick & Ellis, 2003; Hardwick et al., 2005). Often these narratives share the authors' reasons for conducting the program, specific aspects of the programs that were challenging, and suggestions for other educators who would like to conduct a similar program. For example, Gentz (2007) shared her story for why she began a program about native Hawaiian insects, her beliefs about its influence on students entering entomology, and her future plans for the program. While this article does focus on specific insects, the author does not offer an overview of activities for other educators to adopt, but rather shares the unique story of how she established her program.

Other entomology education articles concentrate on methods for studying insects rather than on one species or group of insects. These publications focus on the reasoning behind their particular teaching methods and educational approaches, as well as their perceived benefits of using this method. Some of this literature demonstrates how to use the 5E instructional method of instruction to teach about insects, which stresses engaging students in hands-on activities to explore a topic (Akcay, 2013; Brown, 2006). Most of the entomology education articles that focus on teaching methods, however, use experimentation as their way to delve into entomological topics, including insect homes, external characteristics, and bug behavior (Biggs, Miller, & Hall, 2006; Cox, 1991; Danoff-Burg, 2002; Ernst, Vinke, Giberson, & Buddle, 2013; Fay, 2000; Geoghegan, 2000; Glanville, 1998; Hadley & Korb, 2007; Kleintjes, 1996; McLure, 1995; Moore, Chessin, & Theobald, 2010; Parrott, 1999; Rivers, 2006; Yip, 2000). These articles show that conducting experiments in entomology are important to many educators in entomology education, and that this approach has many benefits for student learning. To explore insects that dwell in rotting logs, Biggs (2006) and his colleagues asked students to collect the different insect species they found in dead logs then observe them to formulate questions about these creatures in this unique habitat. Insects were identified and sorted to show the number of specific species found in the logs in total, after which the class of fourth graders held a discussion about different ways to interpret the data. This article and the many others that use experimentation to explore insect topics show that this teaching method is a successful way to approach teaching entomology, either the field overall or more specific topics. While none of these articles evaluated their insect programs for their impact on students, they are important for showing other entomology educators viable methods for teaching about insects.

A few published articles in entomology education report research results, and these reports suggest that there is one key theme in this field – that focused lessons on insects can increase student understanding of entomological topics. Three studies were conducted that examined if students of varying ages would show increased knowledge when given entomology curricula, including lifecycles and insect pollinators (Barrow, 2002; Rao et al., 2007; Shepardson, 1997). All three studies found that students increased their understanding of insect topics, but the results ranged from minor changes to larger impacts, which may be more due to the data collection technique and analysis than the teaching methods. Two of the studies were conducted in elementary school classrooms and used interview data to determine if students understood insect lifecycles. One study interviewed students directly after their insect lessons, and the researcher was present during the entomology education, which allowed him to know what was taught and which specific student learning activities were presented (Shepardson, 1997). Another study in 2002 was conducted by teachers enrolled in a summer course, and they interviewed five students in their community but were unaware of what the students had been taught, relying only on their ability to draw out information from the participants (Barrow, 2002). The first study found a higher level of understanding by the students than the second study, but it was also much more focused and incorporated other types of data into its thematic analysis, including observations and student journal entries. The research findings in these three studies suggest that entomology education programs do have an impact on student understanding of insect topics, but that more research is needed to determine the depth of that impact.

1.4 Education with Entomology

While entomology education involves teaching about insects, many educators teach other subjects with the use of insects and insect topics, which may be called education with entomology. This category of lessons is not focused on entomological subjects and objectives are not to educate about insects, but they use insects as part of the teaching method to achieve goals in other subjects such as science, mathematics, and the literary arts. For science education specifically, some of these lessons have been published as ways to share different activities and topics, others have focused on teaching a particular scientific method, and a few have conducted research on their educational instruction with the use of insects.

Because entomology is a science, it may be easier for teachers to use insects as a way to teach about many different scientific concepts and topics. Two main themes in many published articles about education with entomology are the ways that insects are used to teach ecological concepts and physics. Ecology can be a difficult topic to teach to students as it is not necessarily something that can be easily seen in nature, and especially not in a classroom, as a main objective of ecology is "to explain the abundance and distribution of organisms through their interactions with the environment and other organisms" (Barber, 2012, p. 513). Insect size and short lifecycles may allow teachers the ability to demonstrate these concepts more easily than with other animals, and to offer students a more tangible way to learn difficult ecological topics. These articles offer specific lessons and activities that use insects to teach ecology through observations and experiments with insects, either live specimens or insect representations (Barber, 2012; Culin, 2002; Kelk, 2009; Matthews et al., 1997). Some articles offer steps necessary for educators to replicate the activities in their own classrooms, including educator tips and suggestions for materials for the selected insect study organism (Metcalfe, Marcal, & Gaston, 2000; Morris, 1999; Pyle, Koballa, Matthews, & Flage, 1997; Rop, 2008). Barber (2012) wanted his students to understand the connection between animal camouflage and their likelihood of being attacked by a predator, so he used insect examples to teach the ecological concepts but then students were asked to create a clay caterpillar based on what they learned. Experiments on their creations were conducted to see how they would "survive" in the wild with predators. These activities were aimed at strengthening student understanding of how animal behavior, appearance, and even shape influence their ability to survive in particular habitats, and using insect concepts and physical representations allowed the students a more hands-on approach to this ecological topic.

Physics is another main theme found in education with entomology, and many published lessons show how insects can help teach this topic through different methods. Some physics lessons use insects in word problems or to demonstrate certain concepts, while others use insect experimental models for students (Guyton & Connington, 2013; Ornek, 2008; Robertson & Meyer, 2010). Experiments in physics can help to demonstrate difficult concepts, and entomology can be a way for teachers to give real-life scenarios and representations of these concepts. Robertson and Meyer (2010) used singing insects, such as crickets and cicadas, as tools to teach the physics of sound and the production of sound waves. Not only do insects in this lesson provide students with an actual example of the use of sound in nature, but insect sound production and their use of sound have been extensively researched so many facts and resources are available for educators to utilize in the classroom. These articles about teaching physics and ecology demonstrate the versatility of entomology in education, providing specific lessons and activities that were enhanced because of the use of insects.

Part of teaching science is instructing students about different ways that science is conducted, such as through experimentation and the scientific process. Teachers can reach these goals through the use of entomology in the classroom. Numerous published articles illustrate how teachers have educated their students about scientific methods by using insects and insect topics, especially when their goal is to demonstrate how to conduct an experiment (Ball, 1998; Bergman, 2008; Bowen, 2008; Larsen & LeMone, 2009; Miller, 2004; Peard, 1994; Thompson, 1999; Thompson & Sorenson, 2005; Wagler, 2011). These types of articles all use insects and supporting entomological concepts to help students understand the steps involved in conducting an experiment, to study the movements of crickets, behavior of cockroaches, and how temperature influences chirping insects. The objectives of these lessons are not to learn more about entomology, but to show students how the scientific method is applied, and any increased student knowledge of insects is a bonus to this educational experience. Thompson (1999) discussed teaching inquiry methods in science experiments about earwigs, offering readers examples of elementary school student hypotheses and sample observation sheets. While these articles provide successful science experiments with insects, they lack research findings that demonstrate the effectiveness of using entomology in science education. They do, however, show the multiple ways that teachers have used entomology to enhance their teaching of scientific experimentation and student use of the scientific method.

There are a few published articles that provide data on using entomology to enhance science education. However, these studies focus on teacher professional development experiences or prospective teacher education to enhance their understanding of science and their science teaching, rather than assessing student understanding of science through the use of insects. Previously, the non-research based articles were solely about student experiences learning science with entomology, but research articles choose to look at teacher understanding of science when using insects (Golick & Heng-Moss, 2013; Haefner, Friedrichsen, & Zembal-Saul, 2006). Both of these articles evaluated science learning and understanding after teachers completed a science education course that focused on entomology and the use of insects in the classroom, and although their delivery methods differed greatly (classroom instruction or online learning), the key theme of enhancing teacher understanding of science and science concepts through their learning of and experiments with insects was present in both these studies. More research is needed in education with entomology, especially with student populations, but these studies suggest that using insects in science education is a successful method to increase science learning and to illustrate science concepts.

A review of publications of entomology in education indicates many educators use insects to teach about mathematic topics, such as basic counting, estimating, and even population distribution. Some of these articles, however, use insects as examples to achieve other mathematics goals, and the lessons do not include any other learning about insects or background about them to better understand the mathematics problems, such as using insects in word problems and counting the number of wings and legs on insects (Duarte, Hooks, & Clifton, 2009; Schoenfeld & Kilpatrick, 2008; Ward & Dias, 2004). Ward and Dias (2004) completely focused on the mathematics aspects of the insects, such as counting a ladybug population or measuring their habitat, rather than learning about the numbers of wings all insects have. While the students may have inferred insect facts from their counting tasks, the objective of the lesson was to give students interesting ways to learn counting and comparing numbers, not entomology (Duarte et al., 2009). In other lessons, the focus is still on learning mathematical concepts, but students need more background information on insects to be able to complete the activities, such as learning to identify insect characteristics to count local butterfly species (Culin, 2002; Guyton & Connington, 2013). Again, the objectives of these lessons are still based in mathematics, but students are exposed to more entomology in order to reach those goals, such as having to sight identify butterflies in order to learn how to make graphs and tables about population distributions. Population distribution is a common theme in education with entomology, as insect populations are often small and easily found in most habitats, but are still diverse enough to create interesting data for students to analyze and interpret. Guyton and Connington (2013) cited students' natural curiosity about insects as a way to teach more difficult mathematical concepts like population distributions, especially because entomology provides more in depth data analysis, such as the influence of migratory butterflies on these populations and the effect of habitat limitations on groups of insects. These education articles show how entomology can be applied to numerous topics in mathematics, as well as their versatility in this subject as the lesson can include more or less entomological background to reach their particular goals.

Although their application is not as obvious, insects can be important tools in the teaching of the literary arts as well. Many published articles note how student interest in insects has allowed teachers to enhance student assignments in writing. By providing a topic that students are already drawn to, many article authors discuss how using entomology in literary arts has allowed them to add exciting and unique tasks that produce a variety of writing products, including insect myths, songs, poems, and observations (Baumbach, Christopher, Fasinpaur, & Oliver, 2004; Chiappini, Bertonazzi, Reguzzi, Maghel, & Dindo, 2011; Culin, 2002; Guyton & Connington, 2013; Lott & Read, 2012; Prischmann, Steffan, & Anelli, 2009). In all of these examples of entomology used to teach writing skills, students are required to have some background knowledge of insects, but that knowledge ranges from basic insect facts to extensive, species specific research. Culin (2002) discussed how butterfly counting activities can provide students the opportunity to write stories about their observations of these animals in their habitat. On the other end of the spectrum, Baumbach (2004) and her colleagues had students write "autobugographies," where they had to choose an insect to write stories from the insect's point of view, but students first needed to do enough research on their insect to be able to accurately write about them. The objectives of these types of articles are not in entomology, but including insects in their lessons have enhanced the ways in which these educators taught in the literary arts.

While there are few research findings in entomology outreach, entomology education, and education with entomology, these three fields do demonstrate through other types of published articles that educators are teaching about insects or using insects in their curricula to meet a variety of educational objectives. Hopefully, as these three fields continue to grow, more research will be conducted and published to show the impact of teaching about entomology or using entomology as a way to teach other subjects, such as science, mathematics, and writing.

CHAPTER 2. UNIVERSITY-BASED ENTOMOLOGICAL OUTREACH IN THE UNITED STATES

Numerous departments at universities across the United States have outreach programs, and entomology departments are among those with a rich history of offering programs that endeavor to educate the public about insects and related arthropods. According to Pitt and Shockley (2014), "these programs provide opportunities for recruitment, interaction with the public, facilitation of learning for a variety of groups in the community, and promotion of awareness and appreciation of insects (p. 97)." Each of these entomology departments offer programs unique to their audience, have different funding sources, and reflect the interests and expertise of departmental staff, faculty, and students, yet these programs often overlap in topics, activities, and especially passion for teaching about insects. Below is a brief overview of entomological outreach focusing on connections with K-12 education and large, public educational events, and while many universities also offer entomology outreach through extension or for other organizations, such as FFA and 4-H, these forms of entomology education will not be discussed here.

At Cornell University, the Department of Entomology has existed for more than 125 years and currently offers many programs and yearly activities to "effectively communicate the value of arthropods and entomological research to the broader community" ("Department of Entomology", 2015). Their efforts include an arthropod museum with educational displays, a country wide program to locate and identify ladybugs, a training program to prepare undergraduate and graduate students to teach scientific outreach, and numerous other programs by request. The largest outreach event, Insectapalooza, is an annual fall one-day event for roughly 3,000 visitors and includes more than 30 interactive exhibits ("Extension & Public Outreach", 2015). The goal of this event is to "present entomology at a variety of levels from simple 'infotainment,' to charismatic displays of arthropod diversity, to educational interactive displays on research being done in [the] department" (Hamm & Rayor, 2007, p. 12). For three dollars per person, this outreach event offers visitors hundreds of live arthropods to touch, a live butterfly room, bug crafts, cockroach races, mini film festival, and displayed insect collections ("Insectapalooza 2014", 2014; Hamm & Raylor, 2007). Insectapalooza has been described as "an incredible display of creativity and commitment as well as a great variety of applied and formal science" (Hamm & Raylor, 2007, p. 14), and has been requested by administration to occur every year to show the diversity of arthropods and promote entomology.

The Department of Entomology at Michigan State University began its outreach program in 1991, starting with a greenhouse and classroom called the Butterfly House, which hosted presentations, classes, and even weddings (Donovan & Bristow, 2002). In 1996, the Bug House opened to focus specifically on science education using arthropods, and offered student classes, presentations, displays, and a petting zoo, and by 2002, these two facilities hosted more than 14,000 visitors per year (Donovan & Bristow, 2002). In 1998, two programs were added to their outreach offerings, Bug Camp for elementary-aged children, and Bug College which offered in-service teachers a short-course in hands-on science lessons using insects (Donovan & Bristow, 2002). Bug Camp eventually grew to include residential camps for older children to visit labs in the department and learn about entomology careers, and a Junior Counselor program where older children were given training in entomology, then served as assistant counselors in Bug Camp (Parsons, 2014). Budget cuts in the Department of Entomology resulted in the cancellation of these camp programs, much to the disappointment of the public (Parsons, 2014). Also due to these changes in faculty and financial support, the Bug House eventually cut back to primarily offering educational programs and tours for up to 30 visitors, as well as offering free regular open house events throughout the year for the public (“Bug House Visitors”, 2015).

Pennsylvania State University’s Department of Entomology has an active outreach education program, including an arthropod museum, an annual community event called The Great Insect Fair, and the Bug Camp for Kids (Boardman et al., 1999). The department’s arthropod museum, The Frost Entomological Museum, offers the public educational displays and programs for school groups (“Outreach and Education”, 2015), and will soon include a structured docent program and enhanced outreach offerings (“The Frost Entomological Museum”, 2015). The Great Insect Fair, which began in 1993, occurs annually in September with the goal “to share with the public the beauty and diversity of insects, why insects are so important, and what makes them such a fascinating group of animals” (Frazier, 2002, p. 72). This one-day event drew in 1,500 attendees its first year, and by 2001 educated and entertained roughly 5,000 visitors with an insect zoo, observation bee hives, cockroach races, face painting, honey tasting, and display arthropod collections (Frazier, 2002; “The Great Insect Fair, 2015). The

Department of Entomology also offered, until recently, two Bug Camps, one for 8- to 11-year-olds and the other for 10- to 14-year-olds. The Bug Camp for younger students is a day camp for 20 children to learn about insect predator/prey relationships, social insects, metamorphosis, and a range of ecological, environmental, and biological topics ("Bug Camp for Kids", 2015). The Advanced Bug Camp for Kids helps children understand the scientific process through lab visits, observational research, and arthropod experiments ("Advanced Bug Camp for Kids, 2015). The department also offers listings of other entomology-related information from the internet, including identification websites, curriculum materials, pest control guides, and citizen scientist programs ("Outreach and Education", 2015).

The Entomology Education Program is nested in Sonoma State University's (SSU) Field Stations and Nature Preserves, and its goal is to "increase awareness and appreciation for the critical role of insect biodiversity in ecosystems, emphasizing conservation issues such as the necessity for reducing pesticides in both natural and managed systems" (Anderson, 2010). This program provides presentations for schools and the public, including workshops, lectures, classes, and public hikes, as well as travelling exhibits with laboratory equipment (Anderson, 2010; "Sonoma State University School of Science & Technology", 2012). The primary way that the Entomology Education Program receives funds is through Insecta-Palooza, an annual event for the public to explore the world of insects and related arthropods through interactive exhibits and lectures (The Community Voice, 2011). Beginning in 2009, this event draws more than 1,200 participants to its insect zoo, interactive labs, butterfly house and garden tours, silent auction, and musical presentations ("Have a Ripple Effect", 2012; “Sonoma State University School of Science & Technology”, 2012; Wasp, 2009). In 2013, Insecta-Palooza became the SSU Science Festival, joining with other departments to celebrate scientific exploration on campus with a unifying theme, such as the “A Walk Through the Watershed” theme from 2013 (Covington, 2013).

The Department of Entomology at the University of Georgia (UGA) includes a service-oriented, graduate student-governed group called the H. O. Lund Entomology club (“H. O. Lund Entomology Club”, 2014). Although the group provides venues for social and professional interactions and represents students on a variety of committees, their primary mission is to provide outreach programming at UGA events and local schools (“H. O. Lund Entomology Club”, 2015). Their outreach programs have reached over 5,000 individuals since 2002 through the use of live and preserved arthropods in school-based educational programs, state science fairs, nature centers (“H. O. Lund Entomology Club Outreach”, 2015). These specimens are a part of the UGA Entomology Insect Zoo, which emphasizes hands-on programs and tours to educate people of all ages about insects and related arthropods and their importance on this planet (“Insect Zoo Welcome”, 2014). The H. O. Lund Entomology Club also assists the UGA Department of Entomology in hosting Insectival! Family Day, an annual fall event featuring insect games, educational displays, roach races, an observation beehive, and insect tasting (Parks, 2014). This event began in 1992, and now includes an art competition and a popular butterfly release at The State Botanical Garden (“Insectival! Family Day”, 2014). Finally, faculty, graduate students, and staff in UGA Entomology assist in a Bug Camp each summer, and provide elementary students with insect collecting field trips, campus lectures, tours of entomology labs, and hands-on entomology education presentations (“H. O. Lund Club’s Bugcamp”, 2015).

At the University of Illinois at Urbana-Champaign, the Department of Entomology offers a variety of outreach efforts, ranging from online educational materials to in-person outreach programs. A series of illustrations of the insect orders, previously used as teaching aids in the department, are posted online with links to additional taxonomic information (“Insect Illustrations”, 2012). If an insect cannot be identified through these drawings, the community can email volunteer outreach entomologists in the department for assistance (“Insect Questions?”, 2014). The University of Illinois at Urbana-Champaign also offers the public a science center devoted to pollinators called the Pollinatarium (“UI Pollinatarium, 2014). The Pollinatarium includes educational displays and interactive exhibits on many pollinator topics, including monarch butterflies, history of beekeeping, pollinator games, mammal pollination, and an observation beehive (“Displays and What’s Coming”, 2009; “Exhibits”, 2009). In addition to housing the Bee Research Facility, the Pollinatarium is also home to Beespotter, an engaging citizen science program to monitor Illinois honey bee and bumble bee abundance and distribution (“Description”, 2013). The Department of Entomology also hosts the annual Insect Fear Film Festival, which began in 1984 and shows a few feature-length and short bad science fiction films focused on insects and related arthropods based on a chosen theme (Weiss, 1989). One reason for hosting this event is to counter the misinformation about insects found in entertainment, so between the shows entomology graduate students provide other insect-related events, including the selling of insect treats, an art contest, and a petting zoo of arthropods featured in the films (Berenbaum, 2014).

2.1 Entomological Outreach at Purdue University

The goal of the Insect Educational Outreach program in the Department of Entomology at Purdue University is to use insects and other arthropods to promote science education by offering engaging educational programming to emphasize the diversity, ecology, biology, and novelty of insects ("Insect Educational Outreach", 2015). This outreach program began almost 25 years ago (Wilson, 1991), and has evolved to include a variety of educational efforts. The Insect Education Outreach program offers a myriad of online educational materials, including care and rearing information, lesson plans, activities, interesting articles, and an activity book, all of which focus on insects, their behaviors, body characteristics, and how to control when they become pests ("Insect Educational Outreach Teacher Resources", 2015). The department also offers in-person outreach programming, both on and off-campus, ranging from small group tours to campus wide events. Requests for tours of the department and educational presentations on- or off-campus, informally known as "Talks and Tours", are fulfilled by faculty, staff, and students from the department. Those who ask for these programs can request the specific topic or topics to be discussed, and all audiences, from preschoolers to seniors, are welcome to request a presentation or tour ("Insect Educational Outreach Teacher Resources", 2015; "Program Requests: Purdue Entomology Outreach", 2015). These programs range greatly, from small groups to tour the insect specimens in the department to presenting at state-wide fairs and festivals. Between 2000 and 2014, the Talks and

Tours program has, on average, provided programming for over 3,700 people per year (data from 2009-2011 not included due to unavailability), with over 15,000 adults and children participating in programs in 2012.

Three of the major annual events hosted by the Insect Educational Outreach program at Purdue University are the Butterfly Encounter, Insectaganza!, and Bug Bowl ("Insect Educational Outreach Events", 2015). The Butterfly Encounter provides local residents the opportunity to learn about butterflies common to Indiana to celebrate their diversity and beauty by counting the different species found at a selected location ("Tippecanoe County Butterfly Encounter", 2014). This event occurs every summer in July at a natural setting known for having a variety of butterflies, currently at the Evonik Corporation's Tippecanoe Laboratories Wildlife Habitat Area in Lafayette, Indiana ("Insect Educational Outreach Events", 2015; "Tippecanoe County Butterfly Encounter Totals", 2014). Starting in 2004, the Butterfly Encounter is co-sponsored by the Evonik Corporation, who provides support through the use of their property, advertising, and supplying drinks and snacks for all volunteers (Hopkins, 2014). The public is invited to join department faculty, staff, and students, regardless of their experience identifying butterflies, to this family-friendly event to learn more about butterfly biology, such as matching adult butterflies to their caterpillars, caterpillar host plants, and how to plant a butterfly garden (Hopkins, 2014). The Butterfly Encounter asks volunteers to walk through the nature trails identifying butterflies with picture keys and tallying the number found, which is then tabulated for yearly results (Hopkins, 2014; Stewart, 2010a). These results, along with event materials such as helpful guides and keys, are posted online for public viewing (“Butterfly Encounter Event Materials”, 2014; “Tippecanoe County Butterfly Encounter Totals”, 2014).

Insectaganza!, officially entitled “Science on Six Legs: An Insectaganza of Education”, began in 1996 as a response to the overwhelming demand for school presentations from local schools (Stephens, 2001) and to meet teacher requests for insect-related presentations that also meet Indiana State Science Standards (Stewart, 2010b). This event invites the fifth grades from the Lafayette, West Lafayette, and Tippecanoe County school corporations to Purdue University’s campus for the Tuesday of October Break for a full day of insect-related education and activities (“Insect Educational Outreach Events”, 2015; Stephens, 2001). According to Melissa Shepson, the former educational outreach coordinator for the Department of Entomology, “our goals for Insectaganza are to facilitate science education and promote awareness of the field of entomology by engaging students and entertaining them, while also providing them the opportunity to experience a university campus firsthand” (as cited in Stewart, 2010b). Insectaganza provides up to 1,000 fifth graders four entomology education activities, which are often altered or replaced due to changes in departmental staff, the needs of the students, and feedback from the classroom teachers (“Insect Educational Outreach Events”, 2015; “Insectaganza”, 2008). Activities have included grasshopper dissection labs, an insect Quiz Bowl, insect biology presentations, ancient insects, entomology theatre, Insectingo (an insect-themed bingo game), and forensic entomology (“Insectaganza”, 2008; “Insectaganza Crawls Around Purdue”, 2012; Stephens, 2001; Stewart, 2010b). These educational offerings are taught by departmental faculty, staff, and students volunteering their time and expertise to help promote entomology and encourage future scientists ("Insect Educational Outreach Events", 2015).

Purdue University is also the home of Bug Bowl, the largest known insect event of its kind, attracting about 30,000 adults and children each April as part of the Spring Fest weekend (Turpin, 2012). The purpose of this event is to "offer the general public an opportunity to participate in a variety of insect related activities that reinforce the importance of insects in our environment" ("Insect Educational Outreach Events", 2015). This widely popular event started as a classroom activity that accidently went public. In 1990, Tom Turpin, a professor of entomology, decided to hold a small cockroach race for one of his classes on Purdue University's campus as an extracurricular activity to show science can be fun and to create interest in entomology. (Lyon, 1995; Newswise, Inc., 1997; "Purdue Bug Bowl Bigger, Buggier and Better", 1999). During an interview that year with a reporter from a local radio station, Turpin's secretary entered his office with the cockroaches for the races, prompting the reporter to announce on air that Purdue was going to host a cockroach race the following Saturday (Newswise, Inc., 1997). That day, 1,500 adults and children attended the event, and Bug Bowl became a formal event the following year because of such a large response to the cockroach races (Newswise, Inc., 1997).

Bug Bowl has offered a wide variety of insect-related activities, some of which have changed over the years or have been replaced, but all have contributed to this event gaining national exposure for the successful combination of entomology, entertainment, and education ("Purdue Bug Bowl", 2006). Activities for Bug Bowl have included an insect petting zoo, an arthropod observation room, an insect cake decorating contest, a human caterpillar race, a butterfly exhibit, a honey tasting room, insect crafts and face painting, bug games, and an insect art contest (“Insect Educational Outreach Events”, 2015; Newswise, Inc., 1997; “Purdue Bug Bowl Bigger, Buggier and Better", 1999). Three of the most popular Bug Bowl activities are the insects as food demonstrations, cockroach races, and cricket spitting.

The insects as food demonstrations offer the public different recipes that contain insects, such as chocolate chirpy cricket cookies, chocolate covered bugs, caterpillar crunch trail mix, cooked grub bugs, and mealworm chow mein (Kaiser, 2014a; Kaiser, 2014b; Newswise, Inc., 1997; “Purdue Bug Bowl Bigger, Buggier and Better", 1999). According to Tom Turpin, “People all over the world eat insects. Why should we be different at Purdue?” (as cited in “Purdue Bug Bowl Bugger, Buggier and Better”, 1999), and these demonstrations show visitors how to cook insects, inform them of the nutritional benefits, and educate them about entomology (Newswise, Inc., 1997).

The cockroach races at Bug Bowl, called the Running of the Roaches at Roach Hill Downs, host two events for the public numerous times throughout Spring Fest weekend. The first is a tractor pull where Madagascar hissing cockroaches are harnessed to miniature tractors marked with the logos of Purdue University, Indiana University, and Notre Dame (“Insect Educational Outreach Events”, 2015; Lyon, 1995). The main event is on an oval track called the Roach Hill Downs, and it features five American cockroaches painted different colors, given fun names based on current events, running while the announcer narrates the status of the race for the crowd (Lyon, 1995). The cockroach races can help teach the public about the role of these animals in nature, their connection to human allergies, and when cockroaches become pests ("Purdue Bug Bowl", 2006).

A popular activity at Bug Bowl is cricket spitting (Kaiser, 2014b; "Purdue Bug Bowl Bigger, Buggier and Better", 1999). The cricket spitting contest was introduced to Bug Bowl in 1997, and has since become sanctioned by the Guinness Book of Records ("Purdue Bug Bowl", 2006). Tom Turpin got the idea for this event after conversing with a visitor at the insects as food booth about consuming chocolate covered bugs, and the man stated he would spit out the cricket if asked to consume the treat (Kaiser, 2014a). For this activity, adults and children can sign up to spit a brown house cricket (which has been frozen to death prior to spitting) and spit it as far as they can within twenty seconds (Chute, 2014; Kaiser, 2014a). All wings, legs, and antennae of the insect must still be intact upon landing for the spit to be recorded, and volunteers compete against other visitors to Bug Bowl within their division, which is based on age and gender (Chute, 2014; "Purdue Bug Bowl Bigger, Buggier and Better", 1999). According to Tom Turpin, the best way to spit crickets competitively is to "place the cricket in your mouth, lather it up with saliva, curl your tongue around the cricket if you can, tilt your head at a 45-degree angle and expel the insect from your mouth" (as cited in Kaiser, 2014a). Visitors that spit the top five greatest distances are asked to return for the "Spit-Off", where the best distances are recorded to determine the winners (Kaiser, 2014a).

Many of these entomology outreach programs have been offering programming for years, but few university departments have evaluated their programs to determine if their goals are being met. If these evaluations have been conducted, the results have not been released to the public, such as the case with Insectaganza and the Butterfly

Encounter events at Purdue University. Teachers who bring their classes to Insectaganza are asked to supply feedback about the four activities and if they believe their students learned something from the event. The Butterfly Encounter also asks its participants to complete a short survey about their enjoyment of the activities, suggestions for future activities, and the likelihood they will return to the Butterfly Encounter again. These types of assessments are helpful to event organizers to shape future educational offerings, but do not necessarily assist them in determining if the goals of the event are true, nor does it share such information with other outreach providers that may benefit from learning how these events are created, organized, or conducted. This study seeks to help bridge this gap and to determine if entomology outreach programming is indeed offering programs, events, and activities that meet their outreach goals.

CHAPTER 3. ENTOMOLOGY IN THE SCIENCE CLASSROOM: EVALUATING THREE OUTREACH METHODS FOR THEIR EFFECT ON TEACHER AND STUDENT CONTENT KNOWLEDGE

3.1 Introduction

University-based outreach programming can be an important method for local teachers and students to be exposed to new fields of study, while also enhancing classroom learning with new curricula and activities. Outreach is often defined as "a meaningful and mutually beneficial collaboration with partners in education, business, public and social service. It represents that aspect of teaching that enables learning beyond the campus walls, and that aspect of service that directly benefits the public" (Ray, 1999, p. 25). Most universities in the United States have some form of outreach programming, including almost all departments of entomology (Pitt & Shockley, 2014). Entomology is the study of insects, and although insects are the dominant group of animals on this planet with nearly one million species of insects discovered (Triplehorn & Johnson, 2005), few individuals learn about them in school due to negative attitudes towards invertebrates leading to teachers not including this important group of animals in science curricula (Wagler & Wagler, 2013).

Insects dominate all major land-based biomes and are an essential part of ecosystem processes (Samways, 2005). Invertebrates, including insects, maintain most ecosystems and according to Wilson (1987),

> The truth is that we need invertebrates but they don't need us. If human beings were to disappear tomorrow, the world would go on with little change…but if invertebrates were to disappear, I doubt that the human species could last more than a few months (p. 345).

Regardless of their vital role in ecosystems, most individuals only know of a few invertebrates (Pimentel, 1975), and most of those are met with fear, aversion, or disgust (Kellert, 1993). Children often avoid invertebrates because they are very different from humans, including their small size and unique behaviors (Lindemann-Matthies, 2005). These disliked animals are frequently grouped together as "bugs" and labeled as threats due to those few insects that are dangerous or painful to humans and generalizing to other species (Looy et al., 2014). Insects pests only represent 1% of all insect species, yet almost all invertebrates are treated as dangerous or harmful (Wilson, 1992). One way in which to overcome student apprehension is through the inclusion of entomology in classroom education (Bergman, 2008), because providing students with a positive introduction to insects not only eases their fears about this group of animals, but also helps them to understand and respect their important role in this world (Danoff-Burg, 2002).

Despite often fearing insects, children want to learn more about them and their unique lives (Shepardson, 2002), and integrating entomology into school curricula provides students with the opportunity to interact with live insects, study their behaviors, and make firsthand observations of scientific concepts (Miller, 2004). Through education programs, children can become fascinated or maintain their fascination with insects (Cox, 1991; Golick, Heng-Moss, & Ellis, 2010), and educators should capitalize on students' natural curiosity to enhance classroom learning and foster respect for invertebrates (Danoff-Burg, 2002). Teaching with insects can be stimulating for students and generate enthusiasm for entomology and learning (Crump et al., 2000; Geoghegan, 2000), as well as assist individuals in recognizing the value of invertebrates and appreciating their contributions to biological diversity (Kellert, 1993). As students work more with insects, they gain a stronger understanding of the role of invertebrates in ecosystems (Cox, 1991), and using hands-on approaches to teaching science with insects results in entomology being exciting and quite relevant (Danoff-Burg, 2002). Insects as teaching tools are inexpensive, engaging, and effective at increasing student learning and appreciation for insects (Matthews et al., 1997). To further examine using entomology to enhance classroom science education, this study evaluated three common outreach delivery methods for their influence on student and teacher content knowledge of science and entomology.

3.2 Literature Review

3.2.1 Outreach Delivery Methods

According to Pitt and Shockley (2014) “outreach programs are the chief way in which universities, colleges, and departments interact with their communities and…enables departments to educate the community on topics related to their field of study” (p. 97). Of the many possible ways to conduct this outreach programming, Scientist in the Classroom (SC), Teacher Training Workshops (TTW), and Online Curriculum (OC) are three common delivery methods.

3.2.1.1 Scientist in the Classroom (SC)

Schools participating in SC programs invite a guest educator or content expert into the classroom to teach about a specific requested topic, usually at the request of the teacher. This delivery method gives students first hand contact with scientists, giving them the opportunity to learn from and work with professionals, as well as provide students with a new role model (Boyle, While, & Boyle, 2004; O'Brien, 1992). In a study by Laursen, Liston, Thiry, & Graf (2007), the researchers found that teachers often deliberately invited scientists to their classrooms to act as scientific role models for their students, and "they wanted students to see that science was something real people did and enjoyed and that science provided many career and education options. This was something they could not easily provide in their role as teacher" (p. 54). SC programs also provide a unique way to engage the audience with their advanced knowledge of the content, providing students with scientific experiences that are often unavailable from their classroom teacher (Katz & McGinnis, 1999). These outreach programs can engage the students by providing them with a way to see science as real life, connecting what they do in the classroom to the world (Thompson & Sorenson, 2005; Luehmann & Markowitz, 2007). Presenters are a novelty in the classroom, and often these programs can engage students by giving science new and different meaning and a deeper understanding of the content.

Loucks-Horsley and Matsumoto (1999) found that teachers enjoyed having experts in the classroom because they have the knowledge about the content and the skills to demonstrate to the students how to make scientific decisions and explorations. While studies have shown visiting scientist outreach programs to have a positive effect on improving science content knowledge of students (Luehmann & Markowitz, 2007), all outreach programs are not the same and are difficult to evaluate because of their numerous differences, including instructor differences and selected activities (Tomanek, 2005; Goebel, Umoja, & DeHaan, 2009; Ethel & McMeniman, 2000). Due to the nature of the program (reliance on the instructor, changes in expertise and teaching ability), this delivery method is difficult to evaluate because it is site specific and can vary greatly even within the same outreach department.

While students may feel engaged in the content, one major drawback to the visiting scientist program is that teachers are often not connected to the programs, and often do not receive any direct benefits from inviting a scientist to teach. Laursen et al. (2007) found that because teachers are not the target audience in visiting scientist outreach programs, often teachers can feel disconnected to the content and may not gain any knowledge due to their detachment. "When teachers did not actively participate…presentations were less effective, and benefits to both students and teachers lessen" (p. 57). Ethel and McMeniman (2000) support this claim, stating that teachers just observing programs is not an effective way to show how to teach the program because the observers cannot understand the underlying knowledge or motivations behind the lesson.

Finally, visiting scientist programs are often labeled as "unidirectional" and "challenging" due to these programs being created, supplied, and presented by an expert and often not including any input from the teacher (Dolan & Tanner, 2005). Often these programs are scientist-driven, and have no feedback or contact with students or teachers, creating programs that experts may consider effective but may not adequately teach the content (Shepherd, 2008; O'Brien, 1992). Also, experts often underestimate how much time is needed to complete a lesson or have the audience understand the topic, leading to classroom confusion and decreased content knowledge (Boyle et al., 2004; Dolan & Tanner, 2005; Goebel et al., 2009). A study of programs across the United States found that most outreach activities failed to provide sufficient time for the students to understand the content and for teachers to grasp what is necessary to teach the lesson (Boyle et al., 2004).

3.2.1.2 Teacher Training Workshops (TTW)

TTW programs are those that hold professional development events for teachers to provide them with new curricula, activities, materials, and knowledge on particular topics. These workshops can create a better sense of understanding in the classroom when the teacher receives more background information about the topic. Professional development can connect teachers to researchers, new science, and lesson ideas that can be perpetuated for future classes and passed on to other teachers (Garet, Porter, Desimone, Birman, & Yoon, 2001). Successful workshops provide teachers with enough background information and training to give them the confidence they need to teach the program without additional assistance from an expert (Jeffers, Safferman, & Safferman, 2004).

In 2000, Ethel and McMeniman surveyed teachers for their feelings about professional development, and 43% of participants listed access to the expert teacher's thinking as an important part of teacher workshops. Teachers stated that just observing the expert was not enough, and that teachers could only model the program if he/she did not get the knowledge he/she needed to effectively teach the program. This study, however, involved workshops where teachers and the expert had a more intimate training, including reflective sessions, sharing their perceptions, and moving at the pace of the audience. While this type of teacher workshop may be more effective for teachers to access the knowledge of the expert, it is often difficult to constantly offer such a program with personnel, time, and funding.

Reviews of teacher workshops find that, while some very effective and successful programs do exist, most workshops still consist of fragmented professional development classes offering disconnected sessions where teachers passively listen to an expert lecture. Boyle et al. (2004) found that this type of professional development is insufficient to create enough learning on the part of the teacher to change what or how he/she teaches. This one way flow of information does not create a partnership between the teacher and the expert, which "created little reason for teachers to take ownership of the project or to consider using the activities that had been developed in the curriculum" (Tomanek, 2005, p. 29). Teacher workshops need to be more hands-on and involved for the teachers to understand how to make their lessons effective for their students. Teachers need to learn how to communicate the basic content knowledge to the classroom and workshops could be the best way for teachers to get the skills necessary to be successful in teaching outreach curriculum if the workshops were created to meet their needs (Barker, Brown, Chrysler, Foertsch, & Niemi, 2004; Garet et al., 2001).

3.2.1.3 Online Curriculum (OC)

This outreach delivery method has experts and educators develop lesson plans and post them online, and the classroom teacher must take the responsibility of learning the material enough to teach the content to their students. Providing local teachers with new curricula is a simple way to deliver new ideas, science, and activities into the classroom because few materials are required. This delivery method is where many universities and departments begin to develop their outreach efforts (Jeffers et al., 2004), and the internet has facilitated the distribution of learning materials (Barker et al., 2004). With little effort and time, experts can create supplemental materials and resources for local schools that touch numerous topics, but do not require experts to take a great deal of time away from their non-teaching activities. Often the lack of materials or time can influence whether teachers will use the curriculum, as well as if the curriculum presents the content knowledge the teacher requires in her/his curriculum (Taff, Boyes, & Maxted, 2007).

With OC programs, often an additional benefit is that teachers must learn more about the topic to adequately teach the topic, thus leading to their ability to lead the lesson and repeat the lesson plan with additional classes (Jeffers et al., 2004). However, a common weakness with OC programs is the assumptions on the part of the creator. Experts may overestimate what teachers know, their abilities, or the amount of effort they are willing to contribute to a lesson plan, which may lead to an incomplete or incoherent program (Davis & Krajcik, 2005; Loucks-Horsley & Matsumoto, 1999). Some lesson plans may assume what basic knowledge teachers have, leading teachers to disregard the curriculum due to insufficient background information or to feel less confident in their ability to teach the content. Another assumption is that reaching more classrooms is more important than adequately training a smaller number of teachers. “Too often it is assumed that working with K-12 education means curriculum development…which is based on flawed assumptions about impact: that high numbers mean high impact” (Laursen, 2007, p. 170). Davis and Krajcik (2005) found that OC was, individually, effective, but that teachers often required additional information to complete the presentation. The authors state “we emphasize that educative curriculum materials, like any educational innovation, cannot serve as a panacea” (p. 4). More research is needed to determine how these three outreach delivery methods compare in meeting the needs of teachers and their students.

3.3 Methods

3.3.1 Participants

This study sought to determine if students and teachers have a higher content knowledge of science and entomology when taught by an entomologist (SC), when teachers were trained by an entomologist (TTW), or when teachers received no entomological training (OC). Thus, fifth grade classrooms in a Midwestern state were selected for this study because children in elementary school are very interested in living organisms (Lindemann-Matthies, 2005), and the state science standards for this grade adapt well to the use of entomology topics. After randomly assigning the schools to one of the three chosen outreach delivery methods, eight public schools voluntarily joined the study, totaling 15 teachers over twenty classrooms and 518 students (Table 3-1). The schools had predominately white students (78-98%) and all teachers self-identified as white for their ethnicity. Students ranged in age from 9 – 12 years old and teachers ranged in age from 28-57 years old. Teachers self-reported as having no formal training in entomology.

Table 3-1. Distribution of Teachers and Students for the Three Treatments

	Outreach Delivery Method		
	Scientist in the Classroom	Teacher Training Workshops	Online Curriculum
Schools	3	3	2
Classrooms	7	8	5
Teachers	6	7	2
Female	5	6	1
Male	1	1	1
Students	187	208	123
Female	88	111	61
Male	99	97	62

3.3.2 Procedure

To address our research questions, four lesson plans using insects to teach science were developed based on the 5E instructional method (Bybee et al., 2006). These lessons were written to meet fifth grade state science standards with the option of teaching them individually or together as a thematic unit with an optional unifying activity at the end of each lesson. For this study, the lessons were taught as a thematic unit with the optional connecting activity over the course of one academic year from August 2011 to June 2012. All lessons and assessments were separated by at least one month to accommodate busy teacher schedules and at the request of the schools. Lesson 1 focused on the body characteristics all insects share, different insect mouth types, what defines an ecosystem, and how an insect's mouth type and specific ecosystem influences their food selection (Appendix A), and included a presentation with pictures of insects and their specific mouth types (Appendix B). Lesson 2 examined the role of insects in an ecosystem according to their food selections on the trophic pyramid and comparing herbivorous, omnivorous, and carnivorous insects (Appendix C), and its presentation offered diagrams to outline the trophic pyramid levels (Appendix D). Lesson 3 discussed arthropod decomposers and their important contributions to ecosystems (Appendix E), with pictures of decomposers in the presentation (Appendix F). Lesson 4 focused on insect predator/prey relationships and balancing the trophic levels in an ecosystem (Appendix G). All four lessons included the use of live native insects from the students' state in activities, such as praying mantids and milkweed bugs. The optional unifying activity used picture representations of the insects used in that lesson and placed them in a poster of an ecosystem (Appendix H). At the end of the unit the pictures were connected between predators and prey, then removed from the poster to demonstrate the impact of removing certain insects from the food web.

A tenured entomology professor taught the four lessons with provided presentation and activity materials, in his own teaching style, for the SC condition. The same entomology professor conducted two workshops in the TTW condition, one in September 2011 for Lessons 1 and 2, and the other in January 2012 for Lessons 3 and 4. These workshops not only modeled the lesson and activities for the teachers, but also included background information on each topic and time to discuss the lesson content with the entomology professor. Teachers in the TTW treatment were provided with all presentation materials and activities to teach the lessons in their own teaching style for their students. The OC treatment consisted of teachers receiving the lesson plans online with physical materials delivered to their classroom by a researcher, with no interaction with the entomology professor. Lesson plans were posted at times coinciding with the teacher workshops in the fall and winter. A researcher was present to observe each lesson in all three treatments to ensure key elements of the lesson were taught, as well as to deliver live insects for classroom use.

3.3.3 Data Collection and Analysis

3.3.3.1 Students

To determine if students had a higher content knowledge of science and entomology when taught by an entomologist, teachers trained by an entomologist, or teachers with no entomological training, students answered a demographic questionnaire (Appendix I) and content knowledge questionnaires (Appendix J) based on the key elements specific to each lesson and included questions from various levels of Bloom's Taxonomy (Anderson et al., 2000). This assessment was administered three times over the course of the school year: first as a pretest at the start of the study, second as a comprehension (comp) test completed within one week after experiencing the lesson, and the third at least one month after the lesson as the posttest. To compare the three treatments, an Analysis of Covariance (ANCOVA) was conducted using the Statistical Packages for the Social Sciences (SPSS) with treatment as a fixed factor, the class average score as the dependent variable, and the class pretest score as the covariate.

Tukey post-hoc tests and Cohen's d effect sizes were conducted to identify differences between the three treatments. To determine the overall impact of the lesson plans on student content knowledge, paired t-tests were calculated with class average scores.

3.3.3.2 Teachers

Changes in teacher content knowledge for each lesson were also assessed by a demographics questionnaire (Appendix K) and content knowledge questionnaires (Appendix L) created for each of the four lessons, with questions from various Bloom's Taxonomy levels (Anderson et al., 2000), to determine if teachers have a higher content knowledge of science and entomology when passively observing an entomologist, having no contact with an entomologist, or when trained to teach by an entomologist. Teachers were assessed using a pretest-posttest design, with the pretest administered at the start of the study and the posttest given at least one month after viewing or teaching the lesson. An ANCOVA in SPSS was also conducted to determine differences between the treatments, with treatment as a fixed factor, teacher content knowledge score as the dependent variable, and their pretest score as the covariate. Tukey post-hoc tests and Cohen's d effect sizes were calculated for a comparison between treatments, and paired t-tests were used to examine the overall effect of the four lessons on their content knowledge of science and entomology.

3.4 Results

3.4.1 Students

Analysis of student content knowledge data comparing their pretest scores to comprehension (comp) scores found no significant differences between treatments for Lessons 1, 3, and 4. The data for Lesson 2 found a significant increase in scores for students in the TTW condition over those students in the OC treatment ($p = 0.046$), as shown in Table 3-2.

Table 3-2. Student Mean Differences from Pretest – Comp Test for Lesson 2 Comparing the Three Treatments

	Mean difference	Standard Error
TTW – SC	0.04	0.45
SC – OC	1.31	0.51
TTW – OC	1.35*	0.50

* indicates $p < 0.05$

Overall, all students showed significant increases in their content knowledge across all lesson plans when comparing pretest and comp test scores (Table 3-3).

Table 3-3. Mean Differences for Student Content Knowledge, Regardless of Treatment

	Comp test – Pretest	Posttest – Comp test	Posttest – Pretest
LP1	2.44**	- 0.57**	1.87**
LP2	3.92**	- 0.62**	3.30**
LP3	1.33**	0.04	1.37**
LP4	2.28**	- 0.33*	1.95**

* indicates $p < 0.05$, ** indicates $p < 0.001$

For Lesson 1, effect size results indicate that content scores for students in the SC treatment did not increase as much as those in the TTW ($d = .62$) or OC ($d = .65$) treatments. This same trend was found in Lesson 3, with the TTW treatment ($d = .38$) and the OC treatment ($d = .68$) scoring higher than those in the SC treatment. These results are also consistent with those found for Lesson 4, with content knowledge scores for students in the SC treatment not increasing as much as those from the TTW ($d = .47$) or OC ($d = .53$) treatments.

A comparison of student comp test content scores to their posttest scores found no significant differences between the three treatments, but an overall significant decrease in student scores was found for Lessons 1 ($p = 0.005$), 2 ($p < 0.000$), and 4 ($p = 0.047$) (Table 3-3). No significant differences between comp test and posttest scores were found for Lesson 3. Medium effect sizes were found when comparing effect sizes between the three treatments for Lesson 1, with the OC treatment scores lower than those in the SC ($d = .65$) and TTW ($d = .66$) treatments. Analysis for Lesson 2 revealed that students in the TTW ($d = .55$) and OC ($d = .43$) treatments scored higher than students in the SC treatment. Effect sizes of student content knowledge scores for Lesson 3 revealed that students in the TTW treatment scored higher than both the SC ($d = .37$) and OC ($d = .34$) conditions. This trend was also found when comparing comp test to posttest scores for Lesson 4, with students in the TTW treatment scoring higher than students in the SC ($d = .75$) and OC ($d = .44$) treatments.

No significant difference between the treatments was found when comparing the student content knowledge scores from the pretest to posttest scores, although all students scored significantly higher on the posttest for all lessons regardless of treatment (Table 3-

3). Analysis of Lesson 1 found medium effect sizes when comparing the TTW treatment to the SC (d = .42) and OC (d = .47) treatments. Students in the OC treatment did not score as high as those in the SC (d = .96) and TTW (d = 1.34) treatments for Lesson 2, although students in the OC treatment did have higher content knowledge scores for Lesson 3 than students in the SC (d = .89) and TTW (d = .50) treatments. Large effect sizes were found when comparing pretest to posttest student content scores for Lesson 4, with the SC condition not scoring as high as students in the TTW (d = .96) and OC (d = 1.08) conditions.

3.4.2 Teachers

Analysis of teacher data found no significant differences between the treatments for Lessons 1, 3, and 4 when comparing pretest to posttest scores for content knowledge. For Lesson 2, teachers in the TTW treatment scored significantly higher than teachers in the OC treatment (p = 0.009) (Table 3-4).

Table 3-4. Teacher Mean Differences for Lesson 2 Comparing the Three Treatments

	Mean difference	Standard Error
TTW – SC	2.26*	0.71
OC – SC	1.86	1.16
TTW – OC	0.37	1.09

* indicates p < 0.05

All teachers, regardless of treatment, showed a significant increase in their content knowledge scores for Lesson 2 (*p* = 0.002) and no significant differences for Lessons 1, 3, and 4 (Table 3-5).

Table 3-5. Teacher Content Knowledge Mean Differences, Regardless of Treatment

	Final – Base test
LP1	1.27
LP2	1.60**
LP3	- 0.07
LP4	0.13

* indicates p < 0.05, ** indicates p < 0.001

Teachers in the SC treatment scored lower on the content knowledge questionnaire for Lesson 1 when compared to the TTW (d = 1.35) and the OC (d = .51) treatments. Analysis for Lesson 1 also found that teachers in the TTW treatment scored higher than teachers in the OC treatment (d = .66). For Lesson 2, teachers in the SC treatment did not score as high as those in the TTW (d = 1.65) and OC (d = 1.03) treatments. Comparing the pretest to posttest scores for Lesson 3 revealed that again the TTW treatment scored higher than teachers in both the SC (d = .53) and OC (d = .43) treatments. Analysis of teacher content knowledge scores for Lesson 4 revealed that teachers in the TTW condition had a higher content knowledge than teachers in the SC (d = 1.32) and OC (d = .78) conditions.

3.5 Discussion and Implications

3.5.1 Students

The results of this study provide evidence that university-based entomology outreach programming can have an impact on student content knowledge, especially when using insects as the vehicle to teach science. Overall student content knowledge scores, regardless of treatment, significantly increased after each lesson and across the study. This result suggests that the outreach delivery method may not be as crucial to conveying information to students as simply getting the lesson plan and materials out to classrooms. These lessons, regardless of the way they are presented, provide students with opportunities to learn about and interact with local insects, while meeting the requirements of state science standards, which allows students to learn about the important roles of insects in ecosystems while providing them with hands-on science activities. Students in the TTW treatment learned significantly more than students in the OC treatment for comprehension (pretest – comp test), which may be due to the content discussed in that lesson. As indicated by their pretest percentage scores (Table 3-6), teachers in all three treatments did not have a strong understanding of the material in Lesson 2, and those teachers in the OC treatment may have needed more background information for student comprehension of the material. Students in the SC condition also scored higher than those in the OC condition, which suggests that interacting with a content expert is more important to the lesson when teachers are not as familiar with the topic.

Table 3-6. Teacher Percentage Scores by Treatment and Lesson

	LP1		LP2		LP3		LP4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
SC	45.5%	54.4%	38.9%	44.4%	72.2%	72.2%	56.9%	51.4%
TTW	65.7%	75.2%	41.2%	69.8%	80.9%	79.4%	65.5%	73.8%
OC	60%	63.3%	50%	66.7%	72.2%	72.2%	62.5%	58.3%

This research suggests that teachers need additional support when teaching new science concepts to improve student comprehension of the material, and that a small amount of background information provided with a lesson plan may not be enough for students to completely understand the lesson. Online outreach program developers may wish to include interactive tools that allow classroom teachers opportunities to discuss the topic with an expert, ask questions, or view video materials that assist in their understanding of the material and activities. For Lessons 1, 3, and 4, students in the OC treatment gained more content knowledge than students in the other two treatments, possibly due to their teacher's previous understanding of the material. These teachers self-selected to be in the OC condition, and may have had an interest in entomology or been more willing to put in the effort necessary to successfully teach the lesson without any interaction from the expert entomologist. This study suggests that entomology is a successful way to teach science, especially when the teacher is motivated to teach the material, but that additional support from experts may be necessary for difficult or unfamiliar content.

Examining student knowledge retention after each lesson found a significant decrease in knowledge, as expected, as large losses occur in short retention intervals (Custers, 2010). Students in the TTW condition had a higher content knowledge than the other two conditions, suggesting that teachers having access to a content expert may have helped students recall more of the lesson information after a larger amount of time. This result may be due to the combination of teacher training in fifth grade instruction strategies, as well as receiving background information and lesson modeling from the workshops. Students in the OC treatment scored higher in their posttest than students in the SC treatment, which may be also due to their teachers being trained in how to teach to their needs and development level. This research suggests that the most effective outreach efforts for student knowledge are those that combine the knowledge of a content expert and the expertise of a trained teacher for a specific grade level. More research is required to examine the relationship between these three treatments, especially potential explanations for why some students retained the science and entomology knowledge over time.

Analysis for the overall study found that for those lessons where teachers were not as familiar with the material, interacting with a content expert helped increase student learning. This trend is found with Lessons 1 and 2, where the science content was discussed by means of entomology topics that most individuals do not learn outside of an entomology course, such as insect mouth types. As such, students learned more when their teachers were trained to meet the needs of fifth grade students and the teacher had interacted with the content expert. Teachers in the OC treatment may have required additional content support, which may explain their students not learning as much as the students in the TTW and SC treatments. For those lessons where the teacher was more familiar with the content material, interacting with the content expert may have been less important than having been trained to teach this specific audience. Students in the OC treatment learned more than those in the TTW and SC treatments overall for Lessons 3 and 4, for while insects were used to illustrate the science concepts, the topics were probably more familiar to both teachers and students and thus contributed to their overall understanding of the material. Due to the small sample size and uneven distribution of teachers in each treatment, additional research will be necessary to examine these findings in more depth, including interviewing teachers for their feelings when teaching the lessons and whether these results hold true in other school subjects.

3.5.2 Teachers

Analysis of teacher questionnaires revealed that all teachers, regardless of treatment, gained significantly more knowledge for Lesson 2 than the other three lessons. This result may be due to the topics discussed in Lesson 2, which could have contained information the teachers were not previously familiar with, or may have needed more information to effectively teach to their students. Lesson 2 pretest percentages reveal that this lesson is one in which the teachers had the least amount of prior knowledge (Table 3-6), suggesting that including entomology outreach programming in their science instruction increased their understanding of trophic pyramids and classifying insects based on what they eat. Teachers in the TTW condition were found to have learned significantly more for Lesson 2 than teachers in the OC condition, suggesting that access to a content expert is important when using insects to teach science concepts in the classroom. Due to their lack of prior knowledge about Lesson 2 topics, TTW teachers may have benefitted from the expert modeling how to teach the content and activities before having to teach the lessons themselves, whereas teachers in the OC treatment had no such access and would have had to learn the unfamiliar content without assistance.

Overall, teachers in the TTW were found to have gained more content knowledge than teachers in the SC or OC treatments, supporting the claim that trained teachers learn more when participating in professional development workshops that model the lesson and provide additional background from and interaction with the expert. Teachers in the

OC condition may have needed more background on the content in each lesson that the expert provided teachers in the TTW condition, and teachers in the SC condition may have felt not as involved in the lesson and therefore may have not gained the necessary knowledge to teach the lesson themselves (Boyle et al., 2004). This result suggests that having the lesson modeled by and interacting with a content expert may be necessary for teachers to have a better understanding of the material and to improve their teaching strategies (Darling-Hammond, 1998), especially when using an unfamiliar context, such entomology, to teach science concepts. University-based outreach programs that cannot offer such workshops for local teachers may still assist them through the use of online tools that prepare them to teach the lesson, including online interactions with a content expert or videos modeling the lesson and its activities. While additional research with a larger sample size is be needed to confirm these findings, this research suggests that teachers wishing to utilize insects as the vehicle to teach science in the classroom would be best prepared when taught the content and activities by an expert.

3.6 Conclusion

This research demonstrates the success of using entomology and live insects to teach science content to students, as their knowledge significantly increased for both comprehension of the material and over the entire study. These outreach programs exposed students to local insect species and expressed their important roles in ecosystems, as well as meeting the state science standards. Teacher knowledge increased only when they did not have a strong understanding of the material, suggesting that additional content support is necessary when teachers explore new topics for classroom use. While these results are specific to the field of entomology, this research can be applied to other university-based outreach program providers that may benefit from evaluating their own delivery methods, as well as demonstrating the usefulness of these programs in local classrooms. Additional research is needed to further examine the impact of using entomology as the vehicle for teaching science for both students and teachers, as well as to evaluate additional outreach delivery methods to determine their ability to use different contexts to teach science in the classroom.

CHAPTER 4. THE ROLE OF ENTOMOLOGY IN ENVIRONMENTAL EDUCATION: COMPARING OUTREACH METHODS FOR THEIR IMPACT ON STUDENT INTEREST AND TEACHER SELF-EFFICACY

4.1 Introduction

Environmental education plays a vital role in helping students understand not only the world around them, but their relationships to other living things. It is essential to remind individuals that the environment is an extension of themselves so its health is as important as their own (Smyth, 2006), as few Americans have a sufficient understanding of the natural world and environmental issues that will impact the future (Coyle, 2005). Formal education settings were found to be a promising way to use environmental education to promote environmental care, including positive attitudes, behaviors, and basic knowledge (Legault & Pelletier, 2000). Environmental education has since become an important part of public school curricula, and research has shown that when environmental concepts are used to teach science, students held more positive beliefs and attitudes about the environment (Holden, Groulx, Bloom, & Weinburgh, 2011). Previous research has found a positive correlation between student achievement and environmental education, although additional research to examine successful or innovative strategies for teaching environmental education are needed to determine how it supports student learning (Parlo & Butler, 2007). However, a key component to the successful integration of environmental education into the classroom is the teacher and most have not been educated in or trained to teach environmental concepts (Ernst, 2007). According to Mastrilli (2005), environmental education needs to be integrated and consistently taught in school curriculum before teachers will feel comfortable with environmental topics. Teachers that do successfully link school curricula to environmental concepts, especially those found locally, help their students make connections between learning and the real world, which makes the information more concrete and meaningful (Parlo & Butler, 2007). When environmental education is not offered as a part of the curriculum, often outreach programs provide new methods of bringing environmental concepts and issues into the classroom.

According to the North American Association for Environmental Education (2011), environmental education "teaches children and adults how to learn about and investigate their environment, and to make intelligent, informed decisions about how they can take care of it." Learning about animals and their role in the ecosystem is an important part of environmental education, although some animals (such as invertebrates) are not discussed due to negative human attitudes. On this planet, invertebrates represent about 90% of all animal species, yet most people feel fear and a great dislike for them, especially insects and spiders (Kellert, 1993). According to entomologist E. O. Wilson (1987), invertebrates are overall more important in maintaining ecosystems than vertebrates and if invertebrates were to disappear the human race would be unable to survive more than a few months. Despite their great importance to almost every ecosystem on Earth, most people do not have a basic understanding of invertebrate life and are largely unaware of their importance (Kellert, 1993). Prior research has suggested that environmental education should use a variety of strategies at every possible opportunity to teach about invertebrates, including helping students focus on the many insects that are harmless and the great diversity of them in this world (Bixler & Floyd, 1999). Studies with preservice elementary school teachers found that most will not teach about arthropods in their future classrooms even though this group of animals could assist science educators in teaching about ecosystem interactions (Wagler & Wagler, 2013). Using insects as teaching tools is inexpensive, effective, and engaging for students, as well as nurturing students' natural curiosity about the world around them (Matthews et al., 1997). To further examine using entomology to teach environmental education, this study compared three common outreach delivery methods to determine their impact on student intrinsic and teacher self-efficacy.

4.2 Literature Review

4.2.1 Intrinsic Motivation

Intrinsic motivation is found when one engages in an activity for the pleasure and interest in it (Vallerand & Ratelle, 2002). Individuals are motivated to behave in a certain way for their own sake and not for reward or to avoid punishment, or due to pressure from an external source (Deci, Vallerand, Pelletier, & Ryan, 1991). In educational settings, motivation is absolutely necessary for effective instruction as it has been positively correlated with student achievement, such as effort and grades (Bolkan, 2014). However, by getting students excited about course content, this excitement can lead to students enjoying their learning, which can lead to students focusing on the process of learning rather than just their grade or the approval of others (Pintrich, Smith, Garcia, & McKeachie, 1993). Therefore, one research objective of this study was to determine if students have a higher interest in environmental topics and issues when taught by an entomologist, teachers trained by an entomologist, or teachers with no entomological training.

4.2.2 Teacher Self-efficacy

Self-efficacy is defined as "the individual's perceived expectancy of obtaining valued outcomes through personal effort" (Fuller, Wood, Rapoport, & Dornbusch, 1982, p. 7), which is grounded in social cognitive theory (Bandura, 1997). An individual's performance at a task is influenced by their self-efficacy, and it can change based on how the individual rates the results of that performance. When applied to the classroom, teacher self-efficacy is the instructor's belief in his/her ability to organize and deliver those things necessary to accomplish a particular teaching task in a specific context (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). Teacher self-efficacy is influenced by the prior experiences of the teacher, including their successes, failures, and feedback from others (Blonder, Benny, & Jones, 2014). Bandura (1993) stated that "teachers' beliefs in their personal efficacy to motivate and promote learning affect the types of learning environments they create and the level of academic progress their students achieve" (p. 117). Research examining teachers with high teacher self-efficacy have found numerous positive characteristics that are necessary for student learning. These teachers are more open to new ideas and teaching methods that could better meet the needs of their students (Tschannen-Moran & Woolfolk Hoy, 2001), and they are more likely to put more effort into problem solving (Lumpe, Vaughn, Henrikson, & Bishop, 2014). Hence, our study sought to determine if teachers have a higher teacher self-efficacy when trained by an entomologist, passively observing an entomologist, or having no contact with an entomologist.

4.2.3 Common Outreach Delivery Methods

Numerous universities have environmental education outreach programs, ranging in delivery methods from one-time classroom presentations to large assembly programs. Three of the most common methods are Scientist in the Classroom (SC), Teacher Training Workshops (TTW), and Online Curriculum (OC). SC programs are selected by the classroom teacher, inviting an expert into the classroom to teach about a specific subject. This delivery method allows elementary school students to interact with researchers in specific fields, providing the students with role models that may influence future career choices (Jeffers et al., 2004; Goebel et al., 2009). The literature on visiting scientist programs shows that the instructors act as mentors to students, providing them with new knowledge and demonstrating the importance of science in the world (Jeffers et al., 2004). These programs provide additional resources that teachers lack and information that teachers may not feel comfortable teaching due to their limited expertise (Shepherd, 2008; Tomanek, 2005; Luehmann & Markowitz, 2007).

TTW are typically one-day events where experts provide teachers with new curricula, materials, and knowledge focused on one topic. These professional development workshops are considered an effective way to share new research and curricula with multiple teachers over a short amount of time (Luehmann & Markowitz, 2007; Boyle et al., 2004). To effectively motivate change and learning, it is important to have teachers take the role of the student in such workshops (McKinnon & Lamberts, 2014), and modelling effective teaching strategies have been suggested as a way to enhance teacher self-efficacy (de Laat & Watters, 1995). Teachers' perceptions about the usefulness of the training will result in their decision to attend, seek other sources, or to not include the topic in their curriculum (Luehmann & Markowitz, 2007). This decision could influence what types of science students are exposed to, excluding those topics that cannot be effectively taught as outreach programs.

OC is a method where experts write and post lesson plans for classroom use, and the classroom teacher must take the initiative to learn and obtain the materials necessary to convey the information. Providing local teachers with new curricula is a simple way to deliver new ideas, science, and activities into the classroom because few materials are needed by outreach providers. According to Davis and Krajcik (2005), there are many factors that influence the effectiveness of a curriculum.

> Specifically, teachers' use of and learning from text-based curriculum materials depend not only on the characteristics of the curriculum materials but also on the type of teaching activity in which the teacher is engaged, the teacher's own knowledge and beliefs…how those beliefs are aligned with the goals of the curriculum, and the teacher's disposition toward reflective practice (p. 4).

Luehmann and Markowitz (2007) found that partnerships between universities and schools gave teachers amazing access to these resources, which teachers claimed to be important to their curriculum development and students' access to science.

4.3 Methods

4.3.1 Participants

Eight public elementary schools in a Midwestern state were randomly assigned to one of the three delivery method treatments and all fifth grade teachers at each school were asked to voluntarily participate, resulting in 20 classrooms, fifteen teachers, and 518 students in the study (Table 4-1). The fifth grade was selected due to the ability to use environmental and entomological education to meet state science standards. Teachers ranged in age from 28-57 years old, with students ranging in age from 9-12 years old. All teachers identified themselves as white for ethnicity, and the student population was predominately white as well (78-98%).

Table 4-1. Demographic Information for Student and Teacher Participants in Each Treatment.

	Scientist in the Classroom	Teacher Training Workshops	Online Curriculum
Schools	3	3	2
Classrooms	7	8	5
Teachers	6	7	2
Male	1	1	1
Female	5	6	1
Students	187	208	123
Male	99	97	62
Female	88	111	61

4.3.2 Design

To answer our research questions, four lesson plans using insects as the vehicle to teach environmental education were created to meet fifth grade state science standards. These lessons were based on the 5E instructional model (Bybee et al., 2006), and were written to be taught individually or combined into a thematic unit with connecting themes and an optional unifying activity. For this study, the lessons were treated as a thematic unit, included the optional unifying activity, and taught over the course of one school year (August 2011 – June 2012) with at least one month separating all lessons and assessments. The first lesson focused on the definition of an ecosystem, the characteristics all insects share, different insect mouth types, and how an insect's specific ecosystem and mouth type influence their food choices. The second lesson discussed the role of insects in an ecosystem according to their food choices on the trophic pyramid. Insect decomposers and their contributions to an ecosystem were explored in lesson three, and lesson four focused on insect predator/prey relationships and the importance of balancing the trophic levels in an ecosystem. All lessons used live insects in activities native to the students' state, including tobacco hornworm caterpillars and milkweed bugs. The optional activity occurred at the end of each lesson, with a unifying activity at the end of the environmental education unit. This activity used picture representations of all the live insects used during the unit and discussed the results of removing specific predators or prey from their ecosystem. Due to time constraints in the schools, participants were assessed using a pretest-posttest design where testing was separated by two lessons, resulting in a base test (pretests for lessons one and two), a mid-test comprised of the posttests for lessons one and two, as well as the pretests for lessons three and four, and a final test (posttests for lessons three and four).

The SC treatment consisted of an entomology professor presenting the four lessons to each classroom, in his own teaching style, using the provided presentation materials and activities. The TTW delivery method consisted of the same entomology professor from the first treatment conducting two events, one in the fall for the first two lesson plans, and another in the spring for the last two lesson plans. These workshops modeled the lessons for teachers, and included background information for each lesson plan. Teachers were provided with all materials to conduct the activities and taught each of the lesson plans in their classroom, in their own teaching style. Finally, the OC treatment included teachers accessing the four lesson plans online, then teaching each lesson, in their own style, to their classroom with no interaction with the entomologist. Teachers in this treatment were provided with all materials to conduct the activities at the same times as the other two treatments, with the first two lessons posted in September 2011 and the last two lessons posted in January 2012. A researcher was present at all lessons in each treatment to determine if all key elements were taught and to deliver live insects.

4.3.3 Data Collection

4.3.3.1 Intrinsic Motivation

To determine the impact of using entomology to teach environmental education on student interest in this area, Deci and Ryan's (1980) Intrinsic Motivation Inventory (IMI) was administered to all student participants (Appendix M). This assessment is a multi-scaled instrument used to examine the way in which participants relate to a particular activity and their subjective reaction to their experience. Four of the seven subscales were selected for this study (Interest/Enjoyment, Effort/Importance, Value/Usefulness, and Pressure/Tension) totaling 27 questions answered using a 7-point Likert scale. These subscales were modified to focus on the environmental and entomological topics discussed in the four lesson plans, as Bandura (1997) recommended creating assessments of self-efficacy specific to the task being analyzed (Table 4-2).

Table 4-2. Sample Questions from the IMI (Deci & Ryan, 1980), Modified to include Environmental and Entomological Themes.

Subscale	Example Questions
Interest/Enjoyment (IE)	I enjoyed doing the activities with insects very much. I would describe the activities with insects as very interesting.
Effort/Importance (EI)	I didn't put much energy into the activities with insects. It was important to me to do well at the activities with insects.
Value/Usefulness (VU)	I think that doing the activities with insects are useful for understanding different insect roles in an ecosystem. I would be willing to do the activities with insects again because it has some value to me.
Pressure/Tension (PT)	I was very relaxed in doing the activities with insects. I felt pressured while doing the activities with insects.

Student IMI scales were scored according to Deci and Ryan (1980) scoring procedures, then averaged by class for each subscale. To compare the three treatments, a mixed model Analysis of Variance (ANOVA) was conducted using the Statistical Packages for the Social Sciences (SPSS) with time as a random factor, treatment as a fixed factor, and the subscale class average as the dependent variable. For each classroom, the time variable identified the subscale class average score as either the base test score, mid-test score, or the final test score. Tukey post-hoc tests were conducted to determine differences between the treatments, and Cohen's d effect sizes were calculated. To ascertain the overall impact of the lesson plans on student intrinsic motivation, paired t-tests and Cohen's d effect sizes were calculated with the class averages.

4.3.3.2 Teacher Self-efficacy

Participant teacher self-efficacy when teaching environmental education with insects was assessed using The Teachers' Sense of Efficacy Scale by Tschannen-Moran and Woolfolk Hoy (2001) (Appendix N). This measurement consists of 24 questions on a 9-point Likert-like scale, separated into three subscales: Efficacy in Student Engagement (ESE), Efficacy in Instructional Strategies (EIS), and Efficacy in Classroom Management (ECM). These questions were modified to focus teacher responses on their beliefs about teaching an environmental education thematic unit, their feelings about teaching environmental education and entomology, and their confidence in controlling the classroom when using such activities (Table 4-3).

The Teachers' Sense of Efficacy Scale was scored according to Tschannen-Moran and Woolfolk Hoy (2001) for the three subscales. The three treatments were analyzed using a mixed model ANOVA in SPSS with treatment as a fixed factor, time as a random factor, and teacher subscale score as the dependent variable. The same time variable identifiers from the student ANOVA were used to differentiate between the three assessment times. Tukey post-hoc tests were calculated to compare the treatments, as well as Cohen's d effect sizes. Paired t-tests and Cohen's d effect sizes were used to determine the overall effect of the four lesson plans on teacher self-efficacy when using entomology to teach environmental education.

Table 4-3. Sample Questions from The Teachers' Sense of Efficacy Scale (Tschannen-Moran & Woolfolk Hoy, 2001), Modified for the Environmental and Entomological Lessons.

Subscale	Example Questions
Efficacy in Student Engagement (ESE)	How much can you do to help your students value learning about entomology? How much can you do to improve the understanding of a student who is failing during the entomology lessons?
Efficacy in Instructional Strategies (EIS)	How well can you respond to difficult questions from your students when teaching about and with insects? How much can you do to adjust your insect lessons to the proper level for individual students?
Efficacy in Classroom Management (ECM)	How much can you do to get children to follow classroom rules during insect lessons? How well can you respond to defiant students when you are teaching about and with insects?

4.4 Results

4.4.1 Student Intrinsic Motivation

Analysis of student interest data comparing their base test scores to mid-test scores found no significant differences between treatments for all four subscales, but all students showed significant increases in their responses for the IE, VU, and EI scales (Table 4-4). For the IE scale, effect sizes indicate that the SC treatment scores did not increase as much as the TTW (d = .64) or OC (d = .84) treatments. Effect sizes for the VU subscale also revealed this trend, with medium effect sizes found when comparing the SC treatment to the TTW (d = .34) and OC (d = .51) treatments.

Table 4-4. Mean Difference Scores for the Four Subscales of the IMI (Deci & Ryan, 1980) for All Students, Regardless of Treatment.

	Mid – Base test	Final – Mid-test	Final – Base test
Interest/Enjoyment (IE)	0.50**	0.19**	0.69**
Value/Usefulness (VU)	0.58**	0.23**	0.81*
Effort/Importance (EI)	0.48**	0.23**	0.71**
Pressure/Tension (PT)	- 0.04	- 0.12*	- 0.16

* indicates p < 0.05, ** indicates p < 0.001

Analysis for the EI subscale indicated a large effect size in favor of the OC treatment, demonstrating that students in this condition put in more effort and placed more importance on lessons one and two than students in the SC (d = .94) and TTW (d = 1.36) treatments. For the PT subscale, large effect sizes indicate that students in the OC treatment felt more pressure or tension than those in the SC (d = 1.26) and TTW (d = 1.42) conditions.

Comparing student interest results from their mid-test to the final test also revealed no significant differences between the three treatments, but significant overall increases were found for the IE, VU, and EI subscales, as well as a significant decrease for the PT subscale (Table 4-4). Analysis of the IE subscale found a medium effect size when comparing the OC treatment to the SC (d = .41) and TTW (d = .70) treatments. This trend was also found in the VU and EI subscales, with students in the OC treatment indicating placing more value/usefulness and effort/importance than those in the SC (d = .60, d = .84) and TTW (d = 1.18, d = 1.52) conditions for lessons three and four. Minimal effect sizes were found for the PT subscale when comparing mid-test to final test student interest scores.

When comparing the base test to the final test, analysis revealed no significant differences between treatments, yet significant increases were found with all students for the IE, VU, and EI subscales (Table 4-4). Analysis also found that students in the OC treatment found all lessons more interesting and enjoyable than students in the SC (d = .79) and TTW (d = .62) conditions. Students in this condition also showed higher increases over the four lessons than those in the SC (d = .60, d = .94) and TTW (d = .97, d = .1.36) treatments for the VU and EI subscales, respectively. Again, students in the OC treatment indicated more pressure and tension than the SC (d = .40) and TTW (d = .80) treatments.

4.4.2 Teaching Self-efficacy

Teacher data analysis revealed no significant differences between the three treatments when comparing base test to mid-test teacher self-efficacy scores, as well as no overall increases for all teachers. Teachers in the OC treatment also expressed higher teacher self-efficacy for the ESE and EIS subscales when compared to teachers in the SC (d = .76, d = .62) and TTW (d = .69, d = .44) treatments. Scores comparing the mid-test to final test scores found no significant differences between treatments or for all teachers, regardless of treatment. For the ESE and ECM subscales, large effect sizes were found when comparing the OC treatment to the SC (d = 1.16, d = .99) and TTW (d = .70, d = .95) treatments. When comparing the base test teacher self-efficacy scores to those in the final test, no significant differences were found between treatments or when looking at teacher scores overall. Analysis of the subscales revealed large effect sizes for the

ECM subscale where teachers in the OC treatment indicated feeling less self-efficacious in their classroom management than the SC (d = .78) and TTW (d = .86) treatments.

4.5 Discussion and Implications

4.5.1 Student Intrinsic Motivation

This study provides evidence that university-based environmental education outreach can have an impact on student interest in various topics, in this case using entomology to incorporate environmental education in the science curriculum. While no differences were found when comparing the three outreach delivery methods, student scores did significantly increase overall, indicating that their intrinsic motivation towards the environmental and entomological unit increased with each lesson. This finding suggests that the specific outreach method is perhaps not necessarily as important as simply getting the information out to classrooms. Schools that are unable to afford inviting an entomologist to their classroom or sending their teachers to an all-day professional development workshop can still incorporate environmental education outreach activities into their curriculum through online lesson plans created by experts across many contexts and subjects. These lesson plans, regardless of the way in which the topics are presented to the students, can assist teachers in meeting state standards while injecting new environmental topics into the classroom as well as providing students with more information about ecosystems in the local area. This research suggests that universities currently offering environmental education outreach programming may wish to establish a strong online presence in addition to their in-person outreach offerings.

Analysis of the subscales found that students in both the TTW and OC treatments reported more interest and value in lessons one and two than students in the SC treatment. This result may be because these two treatments were delivered by an instructor with more training and experience teaching fifth grade students, and students may have responded favorably to the instructor that could meet their specific learning needs. Outreach programs that utilize instructors trained in teaching specific age groups may enhance student knowledge of the topics, but more research is needed to determine how to match an instructor to the needs of the audience. Students in the OC condition put more effort in and placed more importance on these two lessons than students in the other treatments, which may be due to the lack of contact their teachers had with the entomologist. These teachers needed to put in more energy to teach these lessons as they could not rely on the entomologist to teach the lesson or model the lesson for them, and thus they may have presented the lesson in a way more true to their teaching styles. Students may have viewed this instruction as more like normal classroom teaching than something novel, whereas the students in the SC and TTW may have viewed the lessons as more novel and separate from typical classroom learning. As for the pressure/tension subscale, the teachers in the OC treatment may not have known how to properly handle or work with the live insects as they were not shown by an expert nor had any training in entomology prior to this study. As a result, their students may have expressed more concern about using live animals in the activities as fear and disgust are often reactions to seeing an invertebrate (Bixler & Floyd, 1999; Kellert, 1993). An important part of teaching entomology is getting the audience comfortable with the insects, and working with an entomologist or having one teach the lesson are ways in which to alleviate the tension felt working with these animals. Including videos or explicit instructions on how to handle different insects, as well as more information about their specific habits, may help teachers using online lesson plans to feel more comfortable utilizing invertebrates in their classroom and to assure their students that the animals will not harm them.

For lessons three and four, the students in the OC condition found more interest, value, and importance in the lessons than students in the other two treatments. The two teachers in this treatment may have put more energy into modifying these lessons for their students as the activities and concepts were more complicated than lessons one and two. Concerns about their students understanding the material and working with the larger live specimens may have motivated them to adapt the lessons, as both of these teachers did connect the material to prior lessons, outdoor experiences, and students' everyday lives. These slight changes may have encouraged more student engagement in the material, resulting in an increase in their intrinsic motivation. Lesson plans on the internet may want to encourage teachers to alter the lesson to meet their needs, and may offer suggestions on how to do so from teachers that have successfully taught the lesson in their own classroom. Future studies on how to adapt online lesson plans to different students' needs are important as more teaching materials are being offered via internet.

When comparing the treatments across the entire study, students in the TTW and SC treatments felt less pressure and tension from the lessons than students in the OC condition, which again could be due to a lack of teacher comfort and/or training holding or working with live insect specimens. Insects are not discussed in most classrooms because of a negative attitude, a lack of training, and the teacher's background experience with insects (Matthews et al., 1997). Besides teaching educators about invertebrates and how to utilize them in the classroom, students may benefit from a brief introduction to the specific insects used in that lesson to help alleviate any negative feelings they may have, including how to properly hold them and use them in the activities. Students in the OC treatment, however, responded positively on the other three subscales of the IMI resulting in higher rankings of effort, value, and interest for all four lessons. Again, these scores may be a product of the teachers needing to put more effort into learning and teaching the lessons, which they may have modified to better meet the needs of their students and their own teaching style. Additional research will be needed to examine this finding in more depth, including qualitative interviews and analysis of the materials these teachers created for each environmental education lesson.

4.5.2 Teacher Self-efficacy

Analysis of the teacher assessments suggest that teachers with high teacher self-efficacy will remain at those levels when new environmental and entomological lessons are included in their science curriculum, regardless of the outreach delivery method. Previous research has found in-service teacher self-efficacy to be difficult to change and sustain, and experienced teachers appear to have stable teacher self-efficacy beliefs even when exposed to new teaching methods and professional development (Tschannen-Moran et al., 1998). However, there is also the possibility that these teacher self-efficacy scores are artificially high due to an overestimation of teachers' beliefs of what they should be reporting rather than their own actual teacher self-efficacy beliefs (Holden et al., 2011). These teachers may also be reporting unrealistic optimism about their teaching by rating themselves above average, as many teachers will only select the higher values when assessed for their teacher self-efficacy (Cakiroglu, Capa-Aydin, & Woolfolk Hoy, 2012). Additional research is needed to determine the impact of these delivery methods on teachers with low teacher self-efficacy, if the inclusion of entomology to teach environmental education influenced their feelings about teaching the science unit, and using different teacher self-efficacy measures to triangulate teacher responses with their actual beliefs when teaching the lessons. However, these results show that the use of live insect specimens and entomological topics did not lower teacher self-efficacy beliefs, which suggest that the use of local insects as tools may be an effective way to teach environmental and science topics. This study is limited by its reliance on self-reporting teacher self-efficacy measures, and more research into teacher reasoning for their rankings and beliefs about their teaching would benefit the understanding of this field.

Analysis of subscale data demonstrates that those teachers that had no contact with an entomologist felt less self-efficacious about their classroom management in this teaching environment as the lesson progressed. This result may be that lessons three and four contained more difficult material and activities that built on simpler concepts covered in lessons one and two, or this change may be from the inclusion of larger live insect specimens, including the praying mantid and dragonfly larvae. Teachers in the OC condition also had no additional support to teach these lessons, such as seeing the lesson modelled in the TTW treatment or being able to rely on an expert in the SC treatment, which may result in these teachers feeling less control over how their students will react to the lessons or supervising students handling the live animals. Online outreach programs may wish to include more support for teachers that need additional help, such as supplementary materials, tips from other teachers on conducting activities, and videos of educators modelling the lesson. These aids may help teachers feel more self-efficacious and in control of their classrooms if they see the lesson prior to teaching it or get feedback from other in-service teachers. These conditions may also explain the drop in self-efficacy for these teachers regarding student engagement in lessons three and four, especially if these teachers were less sure of how their students would respond to the larger insect specimens or more complicated activities included in these lessons. Posting videos of the lessons, background information about the insects, or models of how to properly hold such animals may be needed to alleviate teacher concerns about student engagement in these activities.

Teachers working in the OC treatment may also have been more willing to join a condition where they had no contact with an entomologist because of their high and stable teacher self-efficacy beliefs, which may account for their higher rankings at the beginning of the study for student engagement and instructional strategies. These teachers may have felt more confident of their ability to take the information and materials provided and modify them to meet the needs of their students as they were not offered any additional support. The two teachers in this treatment did adapt the lessons more to their teaching styles than those in the other treatments, which also may contribute to their higher feelings of teacher self-efficacy. While a larger sample size will be necessary to confirm these findings, this research suggests that more support may be needed with environmental education lessons including more complicated concepts or less understood animals, like insects, to maintain that high teacher self-efficacy needed to promote student learning. More research is needed to investigate why these teachers chose to participate in such a condition, their reasons behind modifying the lessons as they did, and why other participating teachers chose not to modify the lessons as much. The small sample size is the largest limitation of this study, as teachers are notoriously difficult to recruit into research (McKinnon & Lamberts, 2014), and additional research will be necessary to confirm both student and teacher findings.

4.6 Conclusion

This research demonstrates the important role of environmental education outreach in the classroom, as well as the success of using entomology to teach environmental concepts. Over either two lesson plans (to the mid-test) or four lesson plans (to the final test), these outreach programs increased student interest and enjoyment in the topic, the effort and importance they place on the subject matter, and the value and usefulness they find in that material. These programs can expose students to new environmental topics, how they relate to each other, and their importance in nature, which may influence the value these students place on the environment in the future. Teacher self-efficacy did not decrease over this study, suggesting that using local insects is a hands-on, engaging, cost-effective method to teach about relationships in an ecosystem. While these results are specific to the use of entomology to teach environmental education, this research could be applied to other environmental fields that may benefit from examining their own outreach education programs as well as encourage other university departments to offer these types of programs. Further research such as this should examine possible long-lasting impacts on student interest in environmental and entomological education, and its impact on the teacher self-efficacy of classroom educators, as well as evaluate other outreach delivery methods that may assist in educating the public about important environmental issues.

CHAPTER 5. CONCLUSION

5.1 Results Summary

The results of this study can be separated into two main areas; impact on content knowledge and impact on motivation. For content knowledge, this study sought to determine if teachers and students have a higher content knowledge of science and entomology when taught by an entomologist, when teachers were trained by an entomologist, or when teachers received no entomological training. For motivation, this research wanted to determine if these three types of delivery methods had an impact on student intrinsic motivation and teacher self-efficacy. For students' scores between the pretest and comp test, it was found that only for Lesson 2 did the entomology outreach delivery method impact their understanding of the material, and only when comparing the TTW treatment to the OC treatment. For the remaining three lessons, students in the TTW and OC treatments learned more of the science and environmental material than students in the SC treatment, which may be due to the specific content of those lessons. All students, regardless of treatment, showed significant increases in their content knowledge across all four lesson plans within one week after receiving the entomology outreach, suggesting that the delivery method may not be as crucial as simply getting the lessons and activities to classrooms. No significant differences between treatments were found for the student interest scale from base test to midtest, but all students, regardless of treatment, had higher scores for the IE, VU, and EI subscales. Students in the OC treatment scored higher on the PT subscale, the EI subscale for Lessons 1 and 2, and, along with students in the TTW treatment, for the IE and VU subscales. These results suggest that student interest, value, and enjoyment may be more impacted by the personality and interests of their classroom teacher.

For student retention of this knowledge from the comp test to the posttest, no differences between the treatments were found, and all students showed decreases in their content knowledge of Lessons 1, 2, and 4, probably due to the amount of time between the lesson and that posttest (at least one month). Students in the TTW treatment remembered more of the material from Lessons 3 and 4 than students in the other two treatments. Students in the OC condition did not remember as much from Lesson 1 as the other two treatments which may be due to the larger amount of entomology content in this lesson, but the OC treatment did learn more, along with students in the TTW condition, for Lesson 2 than students in the SC treatment, suggesting that having the classroom teacher a part of the outreach activities may greatly benefit the students. Regarding interest, student scores showed significant increases for the IE, VU, and EI subscales and a significant decrease for the PT subscale between the midtest and final test. No differences between treatments were found. For all lessons, students in the OC treatment had higher scores for the IE subscale, as well as for the VU and EI subscales for Lessons 3 and 4, again suggesting that student interest in a topic may be linked to the teachers' enthusiasm and interest.

From their pretest to posttest, students in all treatments showed significant increases in their understanding of the material, although no differences were found between the treatments. Overall, students in the TTW treatment learned a great deal, as they were found to have higher content knowledge scores for Lessons 1, 2, and 4. Students in the SC treatment were found to have not learned as much for these same lessons, again suggesting that what is best for the students is to include their classroom teacher in entomology outreach events. Students in the OC treatment had high content knowledge scores for Lessons 3 and 4, which may be due to the classroom teachers' familiarity with the materials and topics. The treatment was also found to have no difference for student interest in environmental or entomology education from base test to final test, although all student scores showed increases for the IE, VU, and EI subscales over the course of this study. Students in the OC treatment showed increases in intrinsic motivation for all four subscales over the other two treatments, which may be due to the nature of the treatment where teachers must put in larger amounts of effort, as well as the personality of the teacher because they self-selected to be in this condition, knowing that they would be asked to teach science and environmental education using live insects. Student scores for the PT subscale may have been higher as a result of their teacher not knowing how to hold or interact with the arthropods because of a lack of opportunity to gain this training and information from an entomologist.

As for teachers, those in the TTW treatment scored significantly higher for Lesson 2 than those in the OC treatment, which may be due to familiarity of the teacher with the content of that particular lesson. All teachers, regardless of treatment, scored significantly higher for this lesson as well, implying that this content was new to most participating teachers. Teachers trained by an entomologist in the TTW condition had high scores on content knowledge assessments for all four lessons, suggesting that it is important to have classroom teachers connect with content experts when teaching science and environmental education topics. Teachers in the OC treatment also had high scores for Lessons 1 and 2, which may be due to their lack of familiarity with the material in these lessons prior to teaching, and having to train themselves in the topic to be an effective teacher for their students. All teachers in this study showed no significant increases in their teaching self-efficacy, nor were any differences between the treatments revealed. From the base test to final test, teachers in the OC treatment did not score as high on the ECM subscale as teachers in the other two treatments. However, teachers in the OC treatment did score higher than those in the TTW and SC treatment on the ESE and EIS subscales between the base test and midtest, as well as the ESE and ECM subscales between the midtest and final test, which may be due to the personality of the teachers who chose to join the OC treatment.

5.2 Implications

The results of this study provide evidence that university-based entomology outreach can have an impact on student and teacher content knowledge, as well as student interest and teaching self-efficacy. Previous research has shown that children do not have a firm understanding of insects or their unique behaviors (Barrow, 2002; Prokop, Prokop, & Tunnicliffe, 2008; Shepardson, 1997), and this study demonstrates that students and teachers can learn more about insects, as well as science and environmental education, through the use of insects as vehicles to teach these subjects, by outreach providers connecting entomology experts to classroom teachers. The outreach delivery method was, overall, found to be not as important to student and teacher learning, because the treatments only differed with Lesson 2 from pretest to comp test, with those in the TTW treatment scoring significantly higher than students in the OC treatment. This trend was also found with the teachers in the TTW treatment scoring significantly higher for Lesson 2 than those in the OC treatment. These findings suggest that for content that teachers may not be as familiar with, such as the trophic pyramid in Lesson 2, outreach providers need to give teachers additional support, such as workshops or online videos to model the lesson and review background content, for them to be able to effectively teach the lessons in the classroom. However, for those lessons where teachers may be more confident in their understanding of the material, outreach providers may not need to offer more expensive and time consuming in-person curricular support, instead providing supplemental resources online or in print for teachers to use if needed. Results of this study show no change in teacher self-efficacy, but the chosen assessment did not ask teachers about their confidence in their knowledge of the topic, which may influence their willingness to teach the topic. Future studies may wish to use qualitative data collection techniques to get a more in depth understanding of teachers' feelings and beliefs about teaching science and environmental education using insects.

Another important implication of this research is that teachers and students may benefit from learning how to hold and interact with live invertebrates to reduce their tense and negative feelings towards these animals. Previous research has found that teachers with few interactions with animals led to them being less likely to teach about or with that animal (Randler et al., 2013; Wagler, 2010). Entomology outreach providers can create materials to support teachers using live arthropods in the classroom, such as hosting training sessions or posting videos online of how to properly hold, interact with, and care for these animals. This study also demonstrates that outreach providers can successfully evaluate their programming to ensure that their goals are being met and the programs are meeting the needs of the public. Departments with little money or time can assess their primary audiences to determine how to alter future programming to have the maximum impact while preserving resources.

The findings of this research also indicate that it is important to connect outreach programs more with the classroom teacher, as he/she is trained to teach their specific grade and thus more able to help them learn the material and be more interested in the topics. By showing teachers the many uses of insects in the classroom, including their ability to increase understanding, interest, enjoyment, and value in a topic, more schools may choose to use local insects as ideal specimens to demonstrate numerous science and environmental concepts. Keeping insects in the classroom and using them in daily activities can help to overcome some of the general ignorance of the public about insects, including their lifecycles, exoskeletons, and behaviors (Braund, 1998; Prokop et al., 2008). Working with teachers to create or implement entomology outreach lessons into the school curriculum can also help both teachers and students see the value of insects and their need for conservation, which most individuals do not completely understand (Snaddon & Turner, 2007). According to Shepardson (2002), "taking advantage of children's interests by building on their ideas and structuring curricular and instructional experiences to promote an ecological understandings of insects…is more likely to foster children's conceptual understandings of insects and biological thinking" (p. 642). Insects should be studied by all students as they are a valuable source of biological knowledge and schools should not overlook these animals (Arnett, 1976; Bergman, 1947; Randler et al., 2012).

5.3 Limitations

While this study yielded some interesting results, there were several limitations. First, the number of participants needs to be greater than in this study if these results are to be generalized. This limitation is in part due to the recognized difficultly in recruiting teachers into research (McKinnon & Lamberts, 2014), as well as the amount of classroom time required to participate in the study. More participants would have strengthened the conclusions drawn here, as well as possibly including other demographic factors, such as the inclusion of schools in urban settings, which may have impacted the results of this study. Additional participants may also have resulted in a more even distribution of schools and teachers in each treatment, strengthening the results and generalizability of this research. Another limitation is that the school and teachers in this study self-selected to join, making the participants not as representative of the general population, and certain segments of the population may have opted not to join the study and their results may have differed from those collected during this study. Teachers that chose to participate in this study may have already had interest in entomology or using insects as a part of their teaching, or it is possible that their students had previously expressed an interest in this field, which could have influenced the results for both teachers and students.

As part of this study, all those that would be teaching the lessons were told to teach in their own teaching style. However, one limitation of this study may be that no other guidelines for teaching the lesson plans were discussed, resulting in some teachers modifying the lessons and activities to meet their needs and the needs of their students. While these changes may have benefitted their students by helping them to learn the material and connect the entomology education lessons to prior classroom learning, because some teachers adjusted the materials and others did not, it is possible that the results were impacted by these minor alterations.

5.4 Future Directions

The findings of this study present numerous opportunities for future research, including comparing other outreach delivery methods, moving this research to include new populations, providing students with new opportunities to learn about and interact with insects, and examining connections between the classroom and outreach providers. Some of the results of this research are unclear, and future studies may want to focus on exploring those unique findings such as the reasoning behind some treatments scoring higher than others for a specific lesson plan, the reasons some lessons had a higher impact than others, or why some teachers chose to modify the given lesson materials and whether it truly benefitted their students. Other outreach delivery methods could also be compared for their impact on student understanding of entomology or teaching other subjects using insects as the vehicle, such as large assembly programs, public festivals like Bug Bowl, or educational camp settings. These instructional methods may yield results for a better understanding of public learning during outreach events, and if the goals of these programs are being met. These types of studies could also guide outreach providers for what the public needs for future educational programming, such as videos focusing on working with insects or helping teachers understand the essential roles insects play in specific ecosystems. For instance, a study on a larger insect museum festival found that visitors did not enjoy computers providing insect web pages of information and activities, instead preferring to touch live arachnids, observe social insects, and examine insect fossils (Crump et al., 2000). Additional research will be necessary to determine if these outreach programs are benefitting their audiences, or if modifications are needed to help increase an individual's knowledge and interest in insects.

Future research may also want to focus on diverse populations, such as different grade levels or school settings. This study focused on the fifth grade, but research on younger children, teenagers, or university students may yield additional information on ways to increase their understanding of insects, or to share entomologists' passion for insects with the others. All of the schools in this study were from primarily white, suburban areas, and perhaps moving this type of research to new areas to survey more diverse students would reveal different results from those in this research.

Another possibility for future work is to provide children with new opportunities to interact with insects and learn more about their lifecycles and behaviors. Children are naturally fascinated with moving animals as they are interesting and fun to watch, and entomology outreach delivery methods can build on this curiosity to give new and different experiences to children (Lindemann-Matthies, 2005; Pyle et al., 1997), such as afterschool programs, hands-on activities, and science nights for families. There are not enough opportunities for students to learn about local organisms in their neighborhoods, and helping students find and identify them can strengthen their relationship and understanding of different ecosystems (Lindemann-Matthies, 2005). Providing children with pictures or slides of insects are not enough to teach them about entomology, and often using these substitutes can lead to confusion and misconceptions for students (Hummel & Randler, 2012; Shepardson, 2002). Offering new opportunities to learn about and interact with insects can also help students have a greater appreciation for these animals that are usually viewed negatively (Kellert, 1993), and entomology outreach providers can help children of all ages develop a positive relationship with insects and related arthropods.

Researchers of future studies may want to examine the connection between classroom curriculum and outreach providers as this study's results suggest that a combination of teacher training and content expert may be best for increasing student and teacher understanding of entomology, as well as student interest. Providing new opportunities for teachers and entomologists to interact and develop new lessons may be one way to strengthen entomology outreach programming and assist it in fitting into school curriculum, as well as modeling for teachers how to handle insects to help reduce the fear and disgust felt by teachers and their students (Randler et al., 2012). In a study conducted with preservice teachers creating science lessons using insects as models, the researchers found that the entomology educators working with the education professors were worried about working with children, and the participating teachers were concerned with working with the insects, but together they appreciated each other's expertise and assistance to focus on the goals of the program (Boardman et al., 1999). This study, in addition to the research in this dissertation, provides support that future studies need to focus on connecting outreach efforts with classroom learning, and using both entomologists and teachers to create new opportunities for students to learn about entomology, and to interact with insects. Prior research has found that teachers are interested in learning more about entomology and using insects in the classroom (Akre & Hansen, 1992; Entomological Foundation, 2008), and entomology outreach providers can conduct additional research to examine the strengthens and weakness of this relationship to determine the best teaching tools for using entomology in the classroom. According to Tipton (1976),

> Insects deserve attention. They should be considered, not only because they are linked in a vital way to the well-being of mankind but also for their own intrinsic worth. They provide us with a most unique success story. With a casual flick of the hand or a stomp of the foot we crush an amazing piece of biological engineering that has evolved over millions of years (p. 205).

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APPENDICES

Appendix A Lesson Plan One

LESSON ONE: Are You Going to Eat That? Understanding Ecosystems and Food Choices of the Insect World

Overview: To develop an understanding of what an ecosystem is, what an insect is, and how an insect's specific ecosystem and their mouthparts influence what the insect eats.

Objectives: Students will: 1) explain what defines an ecosystem; 2) identify the characteristics that define an insect; 3) describe the four main types of insect mouthparts; and 4) recognize how an insect's mouthparts influence their food choices.

Key Concepts: Ecosystems, Insects, Food Choices, Insect Anatomy
Subjects: Science, Life Science
Duration: 1 class period (50-60 minutes)
Setting: Classroom with computer and projector
Indiana State Science Standards: Life Science (5.3, 5.3.1, 5.3.2)

Introduction (background for the instructor): Insects may be small, but they are highly adapted to their ecosystem and food preferences. Their mouthparts are so well adapted to their food choices that some insects can only eat solid or only liquid foods. Long ago, ancestral insects had simpler mouthparts, and looked much like millipedes with many legs and segments. Now an insect is defined as an invertebrate animal with three body segments (head, thorax, abdomen), six legs, two antennae, and (if present) one or two pairs of wings. They can be found in almost every ecosystem in the world, and can eat a variety of foods. Looking at the mouthparts can often tell what type of foods they can eat and which of the four types of mouth types they have; chewing, piercing/sucking, siphoning, and sponging. Insects' ecosystems also play an important role in their food choices, often limiting them to specific foods or causing them to be more specialized to what is available in their habitat. Identifying an insect's mouthparts and food choices can help in classifying them according to their role in the ecosystem.

Materials:

Part One:

- Ecosystem poster
    - Tape or magnets
- Shoebox terrarium

Part Two:

- Live insects, each in a separate view box container
    - 6 Bessbugs
    - 6 Painted Lady Butterflies
    - 6 Flies
    - 6 Milkweed Bugs
- Spare set of the four live insects
- Mouthparts Presentation (Microsoft PowerPoint)

Part Three:

- 6 Mouthparts Game Kits
    - One pair of pliers
    - One plastic straw
    - One medium-sized sponge, in plastic bag
    - One toothpick
    - One gumball
    - One plastic bottle of juice or water (brightly colored)
    - One small plate or saucer
    - One orange, or other citrus fruit
- Spare Mouthparts Game Kit
- Mouthparts Presentation (Microsoft Powerpoint)
- Ecosystem Poster
    - Velcro insects

Engagement: To explore these concepts, this activity asks the students to discuss what an ecosystem is. The goal of this activity is to have students think about what makes up an ecosystem, including living and non-living things, as well as size.

1. Break the class into six groups of students (or fewer groups). These students should sit together, either by combining desks or tables. Ask each group to look at the large poster at the front of the room. Tell the class that the poster is a picture of an ecosystem. Ask them to discuss, in groups, what is on ecosystem and tell them that in five minutes, the class will discuss the definition of an ecosystem. You may also conduct this discussion as a class, asking the students to share their ideas of what constitutes an ecosystem.
2. After the five minutes have passed, ask the groups to share what they think an ecosystem might be. After a few minutes, tell them that the definition of an ecosystem is a community of living organisms that interact with the environment and each other. Ask the class if they live in a community. Tell the class that there are two main types of ecosystems: terrestrial (land) and aquatic (water) ecosystems.
3. Ask the class how big an ecosystem is. Typically, students will respond that ecosystems are very large. Ask the students if an ecosystem could fit in a shoebox. After they respond, show the class a terrarium – an ecosystem within itself. Tell the class that this ecosystem has plants, animals, soil, air, and light – so it has everything an ecosystem needs. Ecosystems can be very big, like the ocean, or very small, like the terrarium.

   a. If you would like, you may pass around the terrarium, with the instructions that the lid does not come off. Or you may place it in a location where it can be viewed by all.

WHAT IS AN INSECT?

Activity One:

1. Now that the class knows the definition of an ecosystem, tell them that we are going to meet a few inhabitants of our ecosystem – insects.
2. At this time, it is best to discuss that the class will never be given harmful live insects, and that students are allowed to touch or hold them, but <u>only</u> when told they may, and only if they want to. No students will be forced to touch or hold any live insects. It is also important to review how to work with and handle live animals – including respecting them as another species.
   a. To hold an insect, it is best to use both hands and create a bowl with them, then place the insect in the center of the students' hands. There are also containers available for those that simply wish to view the insects or just touch them lightly.
3. Ask one student from each group to come and get a set of the four live insects in view boxes. Instruct them not to open the boxes yet. Identify the creatures by name only. Remind the students that these insects cannot harm them.
   a. Be sure to pass out the insects AFTER you have given the directions.
4. Tell the class that these animals are insects, and that, as a group, they will be examining these insects to determine what the definition of an insect is. They should look at what ALL the insects have in common.
   a. Remind the students to keep the noise down, and that those boxes that are taped shut should NOT be opened – they fly!
5. After 5-7 minutes, tell the students to return the insects back to their containers, then ask each group to share one thing they believe defines an insect. Continue until the definition of an insect emerges. Ask the students if all insects have wings, and you can have the students guess how many wings insects have (2, 4, 0, etc). The definition of an insect is an animal with three parts to its body (head, thorax, and abdomen), six legs, two antennae, and (if present) one or two pairs of wings.
   a. You can write the parts of the definition on the board to create a list.
6. Ask the groups to look at their insects again and guess at where they may live in our ecosystem (the poster) and what they might eat. Share this discussion with the class.

Explanation:

TYPES OF INSECT MOUTHPARTS

1. Ask the groups to place the containers of live insects to the side of their table.
2. There are four major types of insect mouthparts; chewing, piercing/sucking, siphoning, and sponging.
3. These four types of mouthparts are explained in the PowerPoint presentation, including examples of insects with those mouthparts. This presentation also includes a discussion of how examining insect mouthparts can help determine what it eats.

Exploration:

INSECT MOUTHPARTS AND THEIR ROLE IN AN ECOSYSTEM

Activity Two:

1. Each group should be given a Mouthparts Kit but instructed not open the kit until told to do so. This kit includes the following items: a pair of pliers, a plastic straw, a medium-sized sponge, a toothpick, a gumball, a small plastic bottle of juice/water, a small plate or saucer, and an orange.
2. Tell the students that no one should eat or drink any of the items in the Mouthparts Kit.
3. When ready, ask the groups to open the kit and place all the items in the center of the group. The groups should be told to be very careful with all the items, especially the toothpick and the pliers. The groups should also have one student pour a small amount of the juice/water onto the saucer/small plate.
4. Draw the students' attention to the PowerPoint presentation slide. Discuss with the students that the pliers, toothpick, straw, and sponge represent one of the four main types of insect mouthparts:
    a. If you have time, have the students guess at which mouthparts the items represent, otherwise you can tell the class.
        i. Pliers = Chewing
        ii. Toothpick = Piercing/Sucking
        iii. Straw = Siphoning
        iv. Sponge = Sponging
5. Repeat the same process with the food choice items:
    a. Gumball = Solid foods, including other insects, nuts, seeds, and leaves,
    b. Bottle of juice/water = Liquid foods, including nectar, and leaf juices,
    c. Plate of juice/water = Liquid foods, including blood, leaf juices, and fruit juices, and
    d. Orange = Liquid foods, including insect juices, and leaf juices.
6. Tell the groups that they will be choosing one food item that is appropriate for each of the four "mouthparts", and that they should try to find the best match for each. The class has 5-7 minutes to complete this activity.

Elaboration: Discuss with the class the reasoning behind each correct <u>and</u> incorrect answer, focusing on why that mouthpart can or cannot eat that particular item – and that just because it might be able to eat an item does not mean that it does or will eat that item.

7. Answers:
    a. Chewing: (Pliers + Gumball). Insects with these mouthparts want a solid food, not a liquid (no juice). While the orange is solid, the real nutrients in an orange come from the liquid insides.
    b. Piercing/Sucking: (Toothpick + Orange). Insects with these mouthparts want the liquid food, but their mouthparts are adapted to pierce a hard exterior and suck up the juicy interior. They can drink the juice/water, but they are not specialized for that food item.
    c. Siphoning: (Straw + Bottle of Juice/Water). Insects with these mouthparts want liquid foods, but have adapted to reach low levels or hard to reach tubes to get their nutrients.
    d. Sponging: (Sponge + Plate of Juice/Water). Insects with these mouthparts want liquid foods that are not hard to reach or they create liquid foods by vomiting on solid foods.
8. Ask the groups to return all the materials to the Kit bag.
9. Now that students have seen the different types of insect mouthparts, tell the groups that they will be getting the boxes of live insects back from Activity Two.
    a. The groups should be asked that, for each of the four live insects, they should locate the mouthparts and then classify the insects into one of the four main types of insect mouthparts.
    b. As a class, discuss the correct classification for the live insects, as well as why the groups classified them for each mouthpart type.
    c. Answers:
        i. Chewing: Bessbug
        ii. Piercing/ Sucking: Milkweed Bug
        iii. Siphoning: Painted Lady Butterfly
        iv. Sponging: Fly

INSECTS IN AN ECOSYSTEM

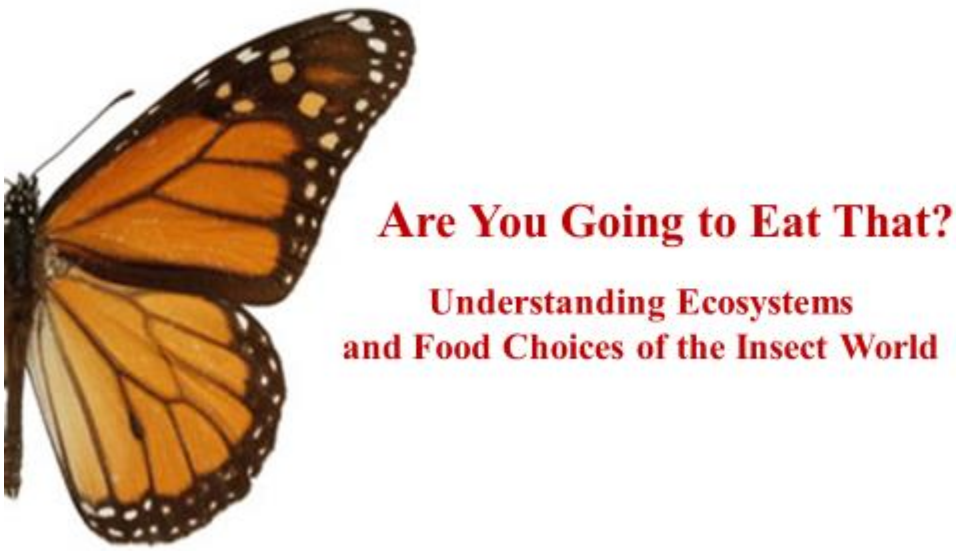
1. Draw the students' attention back to the ecosystem poster. It is currently empty, but has Velcro markers located all around the ecosystem. There are also pictures of the insects used in this lesson with Velcro tabs on the back. Hold up each of the pictures, identify it, then ask the class where that insect would be found (based upon what it eats) in this ecosystem. As a class, have students answer with where they would put the insect and why. For now, no arrows will be used, only the pictures of the insects in this lesson plan.
    a. In general, these areas are best for the insects in this lesson:
        i. Painted Lady Butterfly: A sunny area with plants, possibly flowers.
        ii. Bessbug: Near wood or under leaves, always near the ground
        iii. Milkweed Bug: Near plants, not in trees, but in open areas

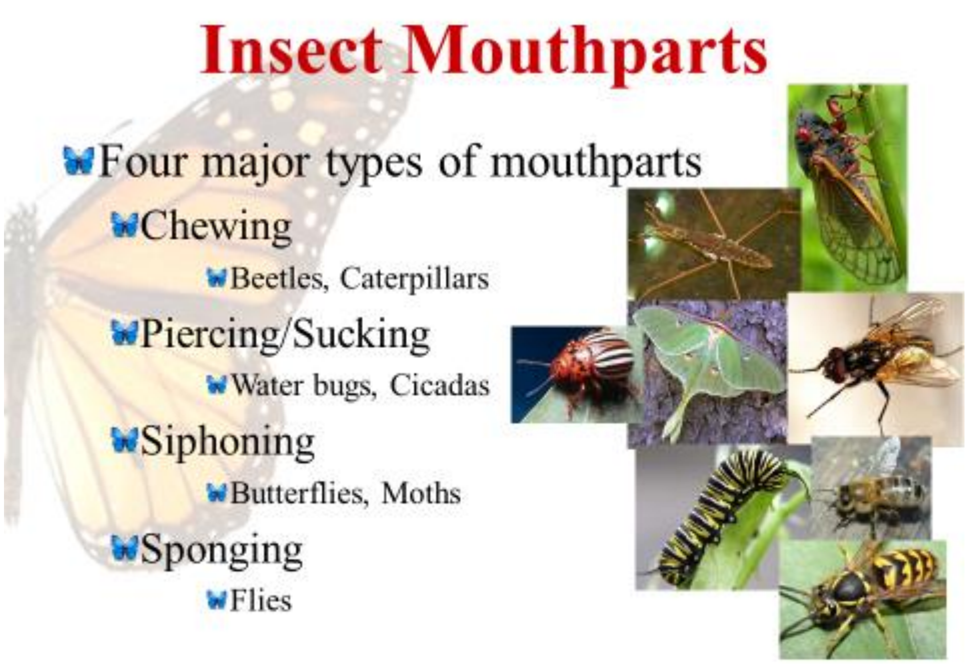
iv. Fly: Near garbage, decaying leaves, near the river for water

2. This poster will remain in the classroom, and will be used for future activities.

QUESTIONS & ANSWERS

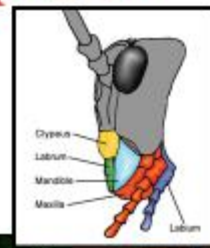
Appendix B Lesson One Mouthparts Presentation Slides





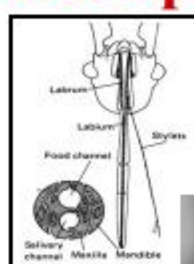
Chewing Mouthparts

- The basic form from which all other types arose
- The most common type
- Insects bite their food
  - Solid foods
  - Great damage
- Other Examples
  - Dragonflies, termites, earwigs, praying mantids, grasshoppers, cockroaches

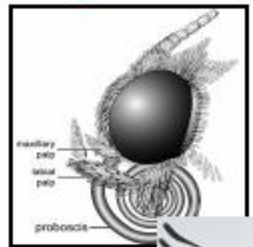


Piercing/Sucking Mouthparts

- Plant or animal feeders
  - Liquid feeders
  - Multiple needles with saliva
- Plant
  - Pierce leaves/stems to suck out plant juices
- Animal
  - Pierce skin to suck blood/body fluids
- Other Examples
  - Mosquitoes, treehoppers, aphids, water striders



Siphoning Mouthparts



- Liquid Feeders
  - Adapted for hard to reach places
    - Inside flowers, treeholes
  - One long sucking straw
  - Curl under head when not in use
- Other Examples
  - Adult Butterflies, moths, skippers




Sponging Mouthparts

- Liquid Feeders
  - Vomit on solid foods
  - Digestive enzymes break down food
  - Sponge up the liquids
- Blood Feeders
  - Cut skin of prey
  - Sponge up blood
- Other Examples
  - None. Only flies have sponging mouthparts.

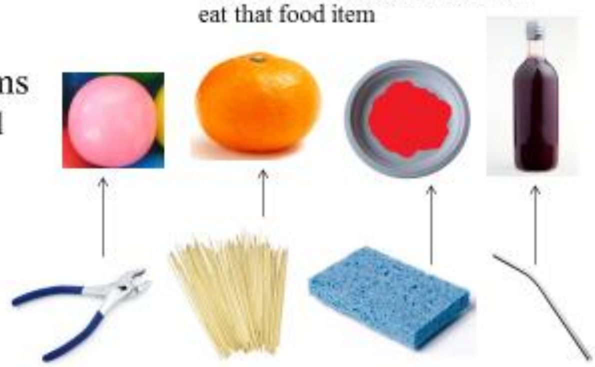


Specialized Mouthparts

- Insect Mouthparts
  - Highly specialized for certain foods
  - Cannot change their food choice
- Examining Mouthparts
  - Determine what type of food choices

Types of Insect Mouthparts

- Mouthpart Items
  - Pliers
  - Toothpick
  - Plastic straw
  - Sponge
- Food Choice Items
  - Bottle of Liquid
  - Orange
  - Gumball
  - Plate of Liquid
- Choose the food item that fits the mouthpart
  - Remember:
    - Insects are specialized eaters
  - Just because it *can* eat the food item does not mean that it *does* or *will* eat that food item



Appendix C Lesson Plan Two

LESSON TWO: Are You Going to Eat That? Understanding the Role and Classification of Insects in an Ecosystem

Overview: To develop an understanding of the role of insects in an ecosystem, how to classify insects based on those roles, and how to sort insects according to their food choices.

Objectives: Students will: 1) classify animals based on their role in an ecosystem; 2) recognize the different types of consumers; and 3) construct a trophic pyramid.

Key Concepts: Ecosystems, Insects, Food Choices, Trophic Levels, Producers, Consumers, Herbivore, Carnivore, Omnivore
Subjects: Science, Life Science
Duration: 1 class period (50-60 minutes)
Setting: Classroom with computer and projector
Indiana State Science Standards: Life Science (5.3, 5.3.1, 5.3.2)

Introduction (background for the instructor): One way to classify organisms is to organize them by what items they choose for food, specifically into two categories; producers and consumers. This classification is a part of the trophic pyramid, which organizes all organisms into what they eat. A trophic level is defined as the position an organism occupies on the trophic pyramid, which combines organisms that all eat similar things, such as plants, animals, or a mix of the two. Insects are all consumers, but they do not all eat the same items. Three categories of consumers are herbivores, omnivores, and carnivores. It is helpful to look at the insect's mouthparts to determine what it eats because the mouthparts are very specialized to the insect's food choices. Once you understand how they eat a particular food and what foods they choose, it is easy to classify them. Producers and consumers play important roles in an ecosystem, and can be found in all types of habitats. Classifying organisms, especially insects, into their appropriate trophic levels helps to understand their role in an ecosystem.

Materials:

Part One:

- Chalk board with chalk or white board with dry erase marker

Part Two:

- Trophic Levels Presentation (Microsoft PowerPoint)
- Trophic Pyramid Activity

    - Trophic Pyramid Poster, double sided
    - Envelope of Photos (40 cards in each)
    - Teacher Envelope of Photos
- 6 live insects, each in a separate view box container
    - 6 Ladybugs
    - 6 Mealworms
    - 6 Milkweed Bugs
    - 6 Cockroaches
    - 6 Crickets
    - 6 Giant Water Bugs
        - Live insects in a bag for each group
- Spare set of six live insects
- Insect Cards

Part Three:

- Ecosystem Poster
    - Velcro insects
- Trophic Levels Presentation (Microsoft PowerPoint)

Engagement: To explore these concepts, this activity asks the students to think about their food choices and how examining food choices can help to classify organisms in an ecosystem.

OUR FOOD CHOICES MATTER

1. Break the class into six (or fewer) groups of students. These students should sit together, either by combining desks or tables. You may use the same groups as in previous activities, or you may change the groups.
2. Ask each group to discuss within their group their favorite breakfast food, and choose one food that they want to share with the class. As the groups share the food, write the foods on the board, and tell the class that these foods will be important for a later activity.
    a. If you are unfamiliar with the food, be sure to ask for clarification – it is important to know what the food consists of for a later activity.

Exploration:

1. Start the Trophic Levels Presentation, which discusses what a trophic level is and how food choices determine where an insect is classified.
2. Share with the class that there are two main categories for organisms on the trophic pyramid; producers and consumers. The presentation slide helps to define “producer” and “consumer”. End on Slide 4 for now.
3. Tell the students that the next activity will ask them to classify common organisms into these two categories of producers and consumers.

TROPHIC LEVELS

Activity One:

1. Each group should receive a Trophic Pyramid Poster and an Envelope of Photos, but told not to open the envelope yet. This envelope contains 40 cards; 20 producers and 20 consumers. Students should be told to keep the poster on side one, where the pyramid is split into two categories (green and red).
2. Before the start of the activity, ask the students where they would place themselves, based on what they had for breakfast. All the groups should agree that they should be placed in the consumer category.
    a. Leave the list on the board for a later activity.
3. Instructions:
    a. Students, when instructed by you to start, will open the envelope and remove all the laminated photos from the envelope. Each group should place them in a single pile, face down, in the center of the group.
    b. Taking turns, each student should start by taking one photo from the pile. The students should show the picture to the group.
    c. On their turn, each student will determine if the organism in their photo is a producer or a consumer. If they need help, students should ask their group for assistance. Groups should think about what the organism eats. If they cannot determine what the photo represents, they should ask the teacher. The Teacher Set has the name and correct placement for each card.
    d. Once they have determined where the organism goes on the Trophic Pyramid, they should place it on the Poster on the correct side.
        i. If the groups need help, draw the students' attention back to their breakfast foods on the board and to think about what organisms eat.
    e. Students should continue to take a photo from the pile and place it on the Trophic Pyramid Poster.
    f. Ask the groups to count how many cards they have on each side. They should have 20 on each side. Discuss as a class if the groups do not have equal numbers.
4. If you would prefer, once all the groups have finished placing the photos, take the Teacher Envelope of Photos and hold each photo up, state the name of the organism, and ask the groups where they placed the organism.
5. The correct placement for each organism is on the back of each card in the Teacher Envelope.
6. Ask the students to remove the photos from the Trophic Pyramid Poster and place them back into the envelope. The poster and envelope should remain, however, in the center of the group for the next activity.

TROPHIC LEVELS IN THE INSECT WORLD

Activity Two:

1. Tell the students that they are going to do the same activity again, but with live insects
2. At this time, remind the groups that none of the live insects will hurt them, and that students are allowed to touch or hold them, but only when told they may, and only if they want to. No students will be forced to touch or hold any live insects. It may be important to review how to work with and handle live animals – including respecting them as another species.
3. Give each group one of each of the six insects in view boxes. Instruct the groups that they will again be classifying the insects into producers or consumers on the Trophic Pyramid Poster.
4. This activity should only take a few minutes because all the insects should be placed on the consumer side of the pyramid.
5. Ask the students to leave the insects on the pyramid, in their view boxes, as they move on to the next activity.

Explanation:

THE DIFFERENT TYPES OF CONSUMERS

Activity Three:

1. Draw the student's attention back to the Trophic Levels Presentation. This portion of the presentation asks the students to think about what different consumers eat. Do humans eat the same items for their food as crickets? Do dogs eat the same items for their food as giraffes? Continue until the end of the presentation (Slide 7)
2. The presentation discusses the different types of consumers, which classifies them based on what foods they eat; herbivores, carnivores, and omnivores.
3. After the presentation, ask the students to carefully take the view boxes off the pyramid and flip the poster over. Side two has the consumer portion of the pyramid split into herbivores, omnivores, and carnivores.
4. Ask the groups to resort the live insects based on what items they consume as food. Let the groups guess at where the insects should be placed before giving the groups the Insect Cards. Then pass out the Insect Cards to resort the insects. Also remind the groups that they can also look at the insects' mouthparts to determine what they use to consume certain foods.
5. After about 5-7 minutes, ask each group to share with the class where they placed one of the live insects.
6. Answers:
    a. Herbivores
        i. Mealworm
        ii. Milkweed Bug

b. Omnivores
    i. Cockroach
    ii. Cricket
c. Carnivores
    i. Ladybug
    ii. Giant Water Bug

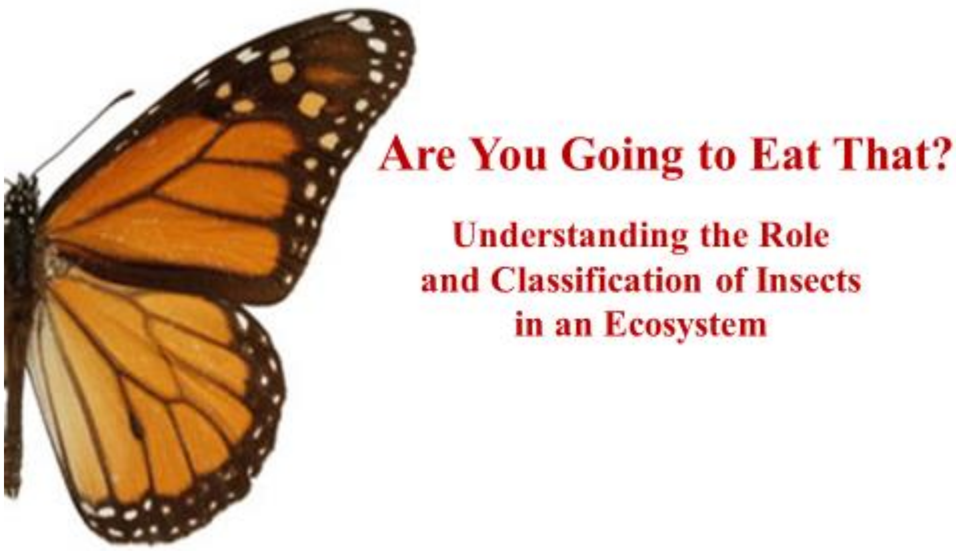
Elaboration:

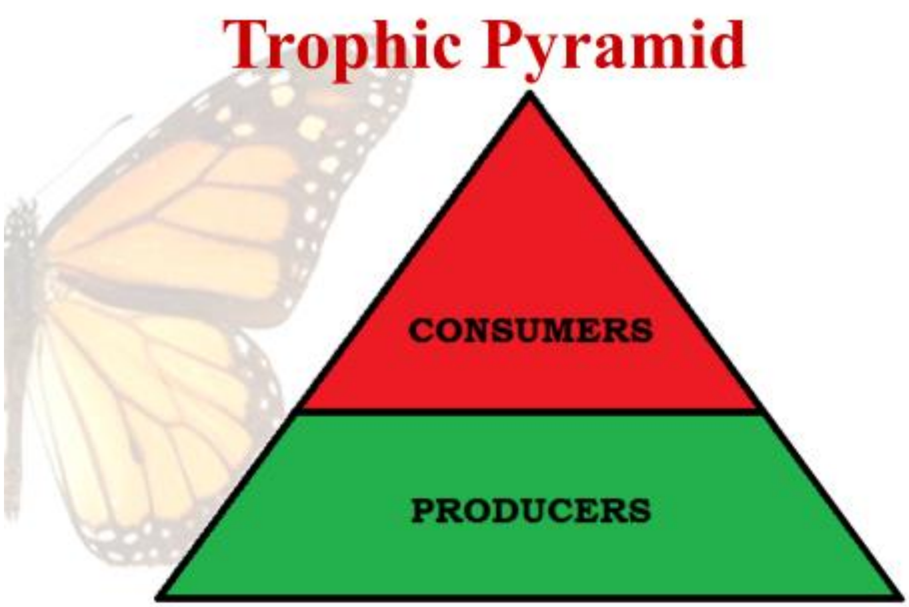
INSECTS IN AN ECOSYSTEM

1. Draw the students' attention to the ecosystem poster. Take the photos of the insects that were used in this lesson and ask the class where they should be placed on the poster based on what they eat and their role in the ecosystem. Also ask the students why they would place them there, based on what they learned today.
    a. In general, these areas are best for the insects in this lesson plan:
        i. Ladybug: On leaves or plants
        ii. Mealworm: On the ground, near dead leaves
        iii. Giant Water Bug: In the water/river
        iv. Cricket: On the ground, near dead things like leaves
        v. Cockroach: On the ground, near leaves or plants
        vi. Milkweed Bug: There is no Milkweed Bug because it is already on the poster from the last lesson.
2. This poster will remain in the classroom, and will be used for future activities.

QUESTIONS & ANSWERS

Appendix D Lesson Two Trophic Levels Presentation Slides



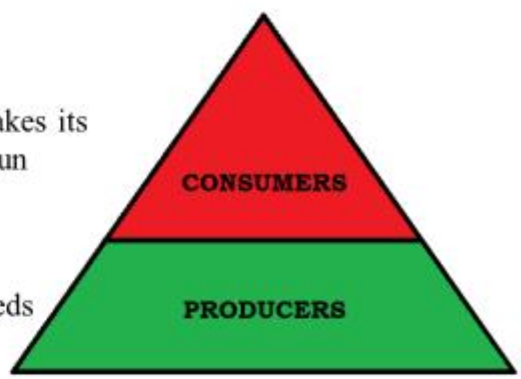


Trophic Pyramid

- Trophic Pyramid
  - Trophic Level: The position an organism occupies on the trophic pyramid
    - Combines organisms that eat similar food types
      - Plants, animals, or both
    - Insects that eat the same type of foods are classified together on the Pyramid

Trophic Pyramid

- Two categories:
  - Producers
    - An organism that makes its own food from the sun
      - Example: Plants
  - Consumers
    - An organism that feeds on other organisms for food
      - Example: Animals



Types of Consumers

- What do consumers eat?
  - Do humans eat the same items for food as crickets?
  - Do dogs eat the same items for food as giraffes?
- There are different types of consumers:
  - Those that eat plants = HERBIVORES
  - Those that eat animals = CARNIVORES
  - Those that eat plants and animals = OMNIVORES

Types of Consumers

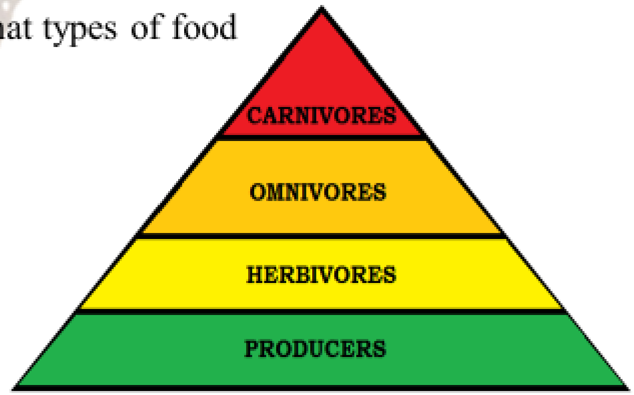
- Herbivores
  - Feed only on plants
  - Examples:

- Carnivores
  - Feed only on animals
  - Examples:

- Omnivores
  - Feed on both plants and animal
    - Examples: YOU!

Types of Consumers

- Classifying Consumers
  - Based on what types of food they eat
    - Animals
    - Plants
    - Both types



Appendix E Lesson Plan Three

LESSON THREE: Are You Going to Eat That? Understanding and Comparing the Role of Insect Decomposers in an Ecosystem

Overview: To develop an understanding of the role of insect decomposers in an ecosystem, how decomposers differ from producers and other consumers, and how important decomposers are in an ecosystem.

Objectives: Students will: 1) describe the role of a decomposer; 2) distinguish between decomposers, producers, and consumers; and 3) identify how decomposers contribute to an ecosystem.

Key Concepts: Ecosystems, Insects, Decomposers, Trophic Levels
Subjects: Science, Life Science
Duration: 1 class period (50-60 minutes)
Setting: Classroom with projector
Indiana State Science Standards: Life Science (5.3, 5.3.1, 5.3.2)

Introduction (background): The trophic pyramid includes another category within consumers besides herbivores, omnivores, and carnivores. Detritivores, also known as decomposers, feed on decaying or dead items that include plants, animals, and wastes. Producers, consumers, and decomposers play very different roles in an ecosystem, with decomposers removing unwanted materials and helping to recycle them into nutrients for other organisms. The majority of decomposers are found on or in the ground, and thus if you want to find them, you often need to pick through soil or decaying organic matter. Decomposers can also be harmful due to their need to consume dead materials. Human items that are made from dead wood are often a target for insect decomposers, such as termites. Other examples of decomposers include bacteria, fungi, and earthworms.

Materials:

Part One:

- Decomposers Presentation (Microsoft PowerPoint)
- 6 Decomposer Kits
  - Part 1: Rotting Log, complete with live insects
    - Bessbugs
    - Carpet Beetles
    - Termites
    - Mealworms

        - Millipedes
        - Woodlice
    - Part 2: Additional supplies and instructions
        - 3 Plastic Spoons
        - 6 View Containers
        - Picture ID Cards

Part Two:

- 6 Decomposer Games
    - Poker Chips
    - Life Cards
    - Role Cards
    - Start Cards

Part Three:

- Ecosystem Poster
    - Velcro insects

Engagement: To explore these concepts, this activity asks the students to explore the role of decomposers and how they contribute to an ecosystem.

THE ROLE OF DECOMPOSERS IN AN ECOSYSTEM

1. Break the class into six groups of students. These students should sit together, either by combining desks or tables. You may use the same groups as in previous activities, or you may change the groups.

Activity One:

1. Start the activity by asking the class to define the terms producer and consumer. If the class cannot find the definition, you may drop hints such as examples of producers and consumers.
    a. Producers: Make their own food
    b. Consumers: Need to find foods for nutrients
2. Once they have found the definitions, review with the class what the consumer level of the trophic pyramid breaks into regarding what an organism eats (herbivores, carnivores, omnivores).
3. Once they have replied correctly, show the complete trophic pyramid from the Decomposers Presentation as a reminder of how the pyramid is arranged.
4. Ask the class where they would place the following insects based on what they eat:
    a. A grasshopper (herbivore)
    b. A dragonfly (carnivore)
    c. A cockroach (omnivore)
    d. A termite (dead wood)

5. If the class replies to the termite with herbivore, tell the class that most termites feed on decaying wood, not trees. Ask them if this information changes their answer.
6. Tell the students that there is another category of consumers, in addition to carnivores, herbivores, and omnivores. There are some animals called detritivores, which eat decomposing, or dead, organisms – including dead plants and animals. Detritivores are often called decomposers because they take things apart in the ecosystem, like dead organisms, and recycle them into useful things that living organisms need, such as soil or nutrients.
7. Some examples of decomposers include:
    a. Mushrooms
    b. Earthworms
    c. Bacteria
    d. Slugs
    e. Starfish
    f. Many different types of insects!

Exploration:

1. Go back to the Decomposer Presentation, which describes what decomposers do in an ecosystem and how they do it. It also provides pictures of example decomposers.

Activity Two:

2. Explain to the class that they have been given a mini ecosystem, a rotting log, where many decomposers can be found. The students should take a few moments to look at the ecosystem, what it is composed of, and what signs of life there may be. Be sure to discuss the instructions before passing out the kits.
3. Distribute the Decomposer Kits to each group, which consists of a plastic container. Remind the groups to look at the containers, but not to open the lid.
4. After the groups have watched the mini ecosystem for a few moments, pass out the second part of the Decomposer Kit, consisting of a plastic bag with plastic spoons, containers, and picture ID cards.
    a. No decomposers in the box can hurt them, and if the group needs help, they should look at the picture ID cards.
    b. Groups can move the dirt and log, but try to keep the dirt in the container.
5. Tell the students that their task for this activity is to search around and under the log, and the surrounding habitat, to find living decomposers. Once they have been located, students should pick them up, very gently with their hand or the spoon and place them in the view containers.
6. It is important to tell the students that the view boxes should be placed close to or in the mini ecosystem so that no decomposers will escape.
    a. Remind the students that they should share the spoons, take turns, and be very gentle with the creatures.

   b. Students should use the picture ID cards to determine which decomposer they have found, and should put the picture ID card on top of the container.
   c. Be sure to tell the students that they should take care not to close the lid of the container on the animal.
   d. Once the group has found and labeled them all, if time, they may share the information found on the back of the picture ID cards.
   e. Students are allowed to touch all the creatures, as long as they are gentle and respect them.
7. Ask each group to pick one decomposer and show it to the rest of the class in a view container. That group should identify it by name and, if time, can share more information about the decomposer, such as if it is an insect or what types of things it may eat.
   a. If you do not have exactly 6 groups, you can read one, double up a group, or ask two groups to share one animal.
8. Groups should not return the decomposers to the box, but secure the lid on the containers and return the containers and box, as well as the bag of supplies.

Explanation:

THE DIFFERENCES BETWEEN PRODUCERS, CONSUMERS, AND DECOMPOSERS

1. Bring the students' attention back to the Decomposer Presentation.
2. Review with the students the differences between the role of producers, consumers, and decomposers.

Elaboration: This activity demonstrates the important role of decomposers in an ecosystem, and what would occur if they were removed.

THE IMPORTANCE OF DECOMPOSERS IN AN ECOSYSTEM

Activity Three:

1. Each group should be given a Decomposer Game, which contains multicolored Life Cards. Each group should take out the cards and put them, face down, in one single pile in the center of the group. The "Life Card" and season should be facing up. The cards move from Spring (green) to Summer (Yellow) to Fall (Orange). There is also a larger START card that begins the game.
2. Tell the groups that each group now represents an ecosystem. To populate this ecosystem, distribute to each student one bag of poker chips. Each group should get at least one Carnivore Bag (all red), one Herbivore Bag (all green), and one Omnivore Bag (red and green). After the group has one of each, the remaining students can be either Herbivores or Carnivores. Only one student in each group will be an Omnivore.

3. Tell the students that their bag contains 6 poker chips and a Role Card that states which insect they have become.
4. These cards will tell the student what insect they are, type of mouthparts, examples of what they eat, and the role they take in the ecosystem; a carnivore, herbivore, or omnivore. The card also reminds the student what it can eat; plants, animals, or both.
5. Explain to the student that because decomposers are often small and do their job without being seen, the decomposer role will not be assigned but will still occur in their ecosystem through the Life Cards.
6. Game Instructions:
    a. The poker chips have two sides; one that states "Waste" and the other which states a food choice of "Plant" or "Animal".
    b. All the students should put their poker chips in the center of the group so that everyone can reach them. To start, all the chips should have the food choice side facing up ("Plant" or "Animal").
    c. To play the Decomposer Game, each student will take a turn picking up the top Life Card from the deck and reading the entire card aloud to the their group. The Life Cards are separated into three seasons; spring, summer, and fall. Groups should start with the spring cards, then summer, then fall. The game is done when all the cards have been read and fall is over.
        i. The group should start with the START card first, then move to the Life Cards. Groups should only take the top Life Card, and not shuffle the cards/pile.
    d. Each Life Card has a different scenario on it that describes what occurs in the ecosystem, and how much food the insects (students) may take from the pile. Students should only take those food choices that they, as the insect, can eat. For instance, herbivores should not take a chip marked "Animal", but a carnivore can. Omnivores can take either type of chip from the pile.
    e. The Life Card also tells the group how much "Waste" they need to put back into the pile. "Waste" consists of animal remains/wastes, dead plants, etc. These are items that the decomposers will eat. Students take the number of chips described by the Life Card and place them back into the pile, now with the "Waste" side facing up. No student can "eat" these chips.
    f. Each Life Card also states the role of a decomposer, instructing the students to turn over a certain number of Waste chips. Each student should turn over the number given, and should only turn over the food(s) they can eat, which remain in the pile in the center. These resources have been recycled back into usable foods for the insects.
    g. The goal of this game is to have the insect (student) survive the season by having enough of their food choices to survive.
        i. There are good events and bad events that happen in this ecosystem. If the group receives too many bad events in a row,

there may no longer be enough food chips for them to survive. The ecosystem can end if each student cannot take the listed number of food chips from the pile.

   h. There are no winners in this game, just to see what happens in each ecosystem.

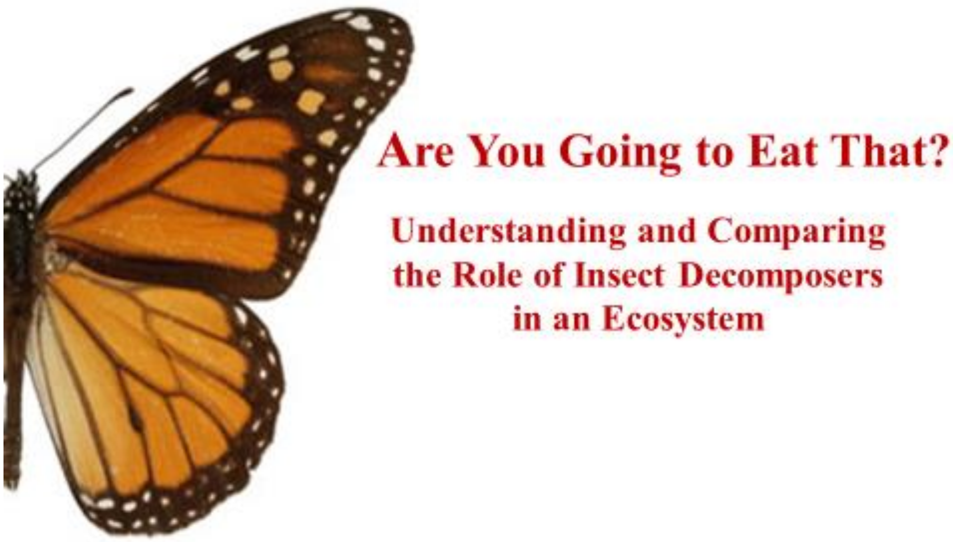
7. After each group has played at least one round, end the activity.
8. Ask the groups if anything interesting happened in their ecosystem – did any ecosystems not survive (no more food chips to take), what type of events happened to their ecosystem and how it changed the decomposers.
9. Finally, ask the students to review why they think decomposers are important in an ecosystem.
   a. Students should return their original 6 poker chips and their Role Card back to the plastic bag.

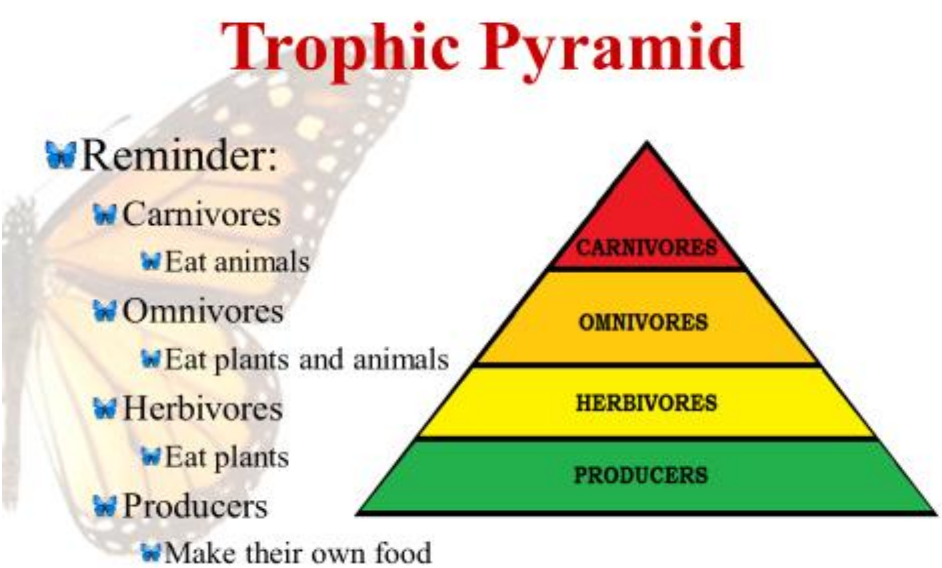
INSECTS IN AN ECOSYSTEM

1. Draw the students' attention to the ecosystem poster. Take the photos of the insects from this lesson and ask the class where they should be placed based on what they eat and their role in the ecosystem. Also ask the students why they would place them there, based on what they learned today.
   a. In general, these areas are best for the insects in this lesson plan:
      i. Carpet Beetle: On the ground, near dead wood or dead leaves
      ii. Termite: On the ground, near dead wood
      iii. Millipede: On the ground near dead leaves or plant matter
      iv. Woodlice: On or under the ground, near dead leaves/plants or wood
      v. Bessbug: There is no Bessbug because it is already on the poster from a previous lesson.
      vi. Mealworm: There is no Mealworm because it is already on the poster from a previous lesson.
2. This poster will remain in the classroom, and will be used for future activities.

QUESTIONS & ANSWERS

Appendix F Lesson Three Decomposers Presentation Slides



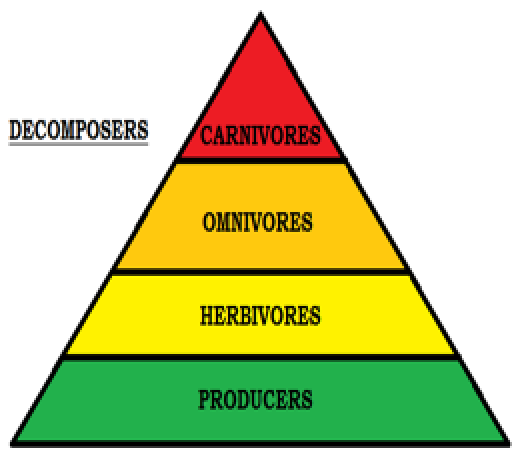


Decomposers

- Detritivores
  - Eat decomposing (dead) organisms
    - Dead plants, dead animals, or waste
  - Also known as DECOMPOSERS
    - Recycle nutrients for other organisms to use
    - Break dead things into very small parts, putting the nutrients in the parts back into the ecosystem

Roles in the Trophic Pyramid

- Producers
  - Provide food and shelter for other organisms
- Consumers
  - Consume plants and/or animals, provide food for other organisms
- Decomposers
  - Consume dead plants and/or animals to recycle nutrients



Why are decomposers not on the Trophic Pyramid?

Appendix G Lesson Plan Four

LESSON FOUR: Are You Going to Eat That? Understanding the Predator/Prey Relationships of Insects in an Ecosystem

Overview: To develop an understanding of the predator and prey relationships of insects in an ecosystem, how to classify insects based on those relationships, and the importance of balancing the trophic levels in an ecosystem.

Objectives: Students will: 1) describe the relationship between predators and prey; 2) classify insects based on their relationships with other animals/plants; 3) explain the importance of balance in an ecosystem; and 4) recognize that organisms in an ecosystem are all connected.

Key Concepts: Ecosystems, Insects, Balance, Predator/Prey Relationships, Trophic Levels
Subjects: Science, Life Science
Duration: 1 class period (50-60 minutes)
Setting: Classroom
Indiana State Science Standards: Life Science (5.3, 5.3.1, 5.3.2)

Introduction (background): Organisms can also be classified by comparing their predator and prey relationships in an ecosystem. By determining what an organism eats and what eats it, it is easy to place the organism on the appropriate level on the trophic pyramid. The trophic pyramid is balanced with predators and prey in an ecosystem, and it is important to keep this balance to ensure that the ecosystem functions well. If the balance is thrown off, either with too many or too few food choices (prey), it can cause the ecosystem to fail and many animals to die. By identifying the predator and prey relationships in an ecosystem, it is easy to see that changes in one part of the ecosystem can create changes in other parts of the ecosystem.

Materials:

Part One:

- 6 Trophic Block Game Kits
    - 22 Insect Blocks
    - Insect ID List

Part Two:

- Live insects, each in a separate view container
    - 6 Praying Mantis

    - 6 Carpenter Ants
    - 6 Dragonfly Nymphs
    - 6 Darkling Beetles
    - 6 Tobacco Hornworm
    - 6 Madagascar Hissing Cockroaches
- Insect Cards

Part Three:

- Ecosystems Poster
    - Velcro insects
    - Velcro/yarn arrows

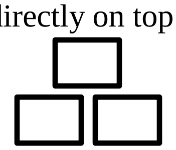
Engagement: To explore these concepts, this activity asks the students to construct a trophic pyramid with insects by thinking about what they have learned about mouthparts, producers, and consumers.

INSECT TROPHIC PYRAMID

1. Break the class into six groups of students. These students should sit together, either by combining desks or tables. You may use the same groups as in previous activities, or you may change the groups.

Activity One:

1. Each group should receive a Trophic Block Game Kit, which contains 22 red and green foam blocks with names of plants and animals them.
2. Instruct each group that they should construct a 3D pyramid based on the trophic levels of insects. They should be told that there are four levels, and each level should contain organisms from the same trophic level. Ask the class if anyone remembers what a trophic level is, and then if anyone can give an example of each level.
    a. Instruct the students that the rough/foam side of the blocks should face up.
    b. Remind the students that these blocks should be placed like bricks – not directly on top of each other but the one above sits over two (below).



3. Groups should create a pyramid that clusters insects from the same trophic level into four levels of a pyramid.
4. For their reference, there is an insect ID list that provides examples of what each insect consumes to aid in placing the blocks in the correct order.
5. After 10 minutes, discuss with the class how they chose to create their trophic level, including where they placed producers, consumers, and decomposers. Be sure to review the correct order if any groups were mistaken with where they placed the insects.
6. This pyramid should have the following order:
    a. Producers (plants) - green level
        i. Blocks

1. Sunflower
2. Grass
3. Leaf
4. Tree
5. Corn
6. Soybean plant
7. Daisy

b. Consumers (herbivores) – red level
   i. Blocks
      1. Cricket
      2. Cucumber Beetle
      3. Milkweed Beetle
      4. Aphid
      5. Katydid
      6. Walking Stick

c. Consumers (carnivores) – red level
   i. Blocks
      1. Earwig
      2. Wheel Bug
      3. Ladybug
      4. Mosquito
      5. Deer Fly

d. Consumers (higher level carnivores) – red level
   i. Blocks
      1. Dragonfly
      2. Giant Water Bug
      3. Tiger Beetle
      4. Robber Fly

7. Check each group's pyramid to ensure that it is structurally sound, for this is important for a later activity.
8. Students should <u>not</u> deconstruct their pyramids after the discussion. Inform them that their pyramids will be used in the next two activities, and that they should be sure not to knock it over.

Exploration:

BALANCING AN ECOSYSTEM

1. Discuss with the class that a trophic pyramid is built on the idea of relationships between organisms that are predators and organisms that are prey.
2. Ask the class if anyone knows the definition of a predator, and if anyone knows the definition of prey. After a small class discussion, reveal the definitions - a predator is an organism that survives by eating another organism and prey is an organism that is eaten by another organism for food.
3. Have the groups look at their pyramids. The level below an organism is its prey level, meaning that it will eat organisms from that trophic level and are the

predator. The level above an organism is its predator level, meaning that it will be eaten by organisms from that trophic level and are the prey. For example, an aphid feeds on the grass in the tropic level below it, but are prey to the ladybug in the trophic level above it. Have the class provide examples, either from their tower or from everyday life to illustrate this point.

4. Discuss with the class that this pyramid is stable and balanced right now because there is enough prey for each predator, and not so many predators that they eat all the prey. For a stable ecosystem, the number of prey needs to exceed the amount that predators need to survive.
5. Tell the class that for the next activity, they are going to play a game where they will see what happens if they remove organisms from the pyramid.
6. Game Instructions:
    a. Each student in the group will, on his/her turn, remove one block from the tower. Students cannot remove a block from the very top level of the pyramid, but they can take blocks from the bottom level.
    b. Once he/she selects a block, the student should carefully pull the block out and place it in front of him/her not on or near the pyramid.
    c. Each student should take a turn until the pyramid collapses (although do not tell the students that this is the result). This game should take a total of 15 minutes. If a group's pyramid falls before this time, they may reset the pyramid and play again.
7. After all the groups have played the game at least once, or for roughly 15 minutes, ask the groups to explain why the pyramids collapsed when they removed too many organisms.
8. When ecosystems are not balanced, and there are too many of some insects and not enough of others, this causes problems in the trophic levels – some insects may not have enough prey and starve to death while others may have no predators and will increase their numbers, causing them to deplete their prey sources. For example, think about if all the dragonflies in the world died, causing mosquito populations to increase – would anyone in the class like that?
    a. Have the students put all the blocks back in the bag, and remove them from the group.

Explanation: The purpose of this activity is for students to understand where to classify live insects on the trophic pyramid based on their predator/prey relationships.

LIVE INSECTS ON THE TROPHIC PYRAMID

Activity Two:

1. To further discuss predator/prey relationships, pass out the six live insects in view box containers to each group. Remind the class that these are living organisms, and should be treated with respect. Also remind the groups that they may touch or hold the insects only if the lid is not taped and only when told. However, they

must be gentle, hold all insects over the desk, and do not have to hold or touch any insects if they do not want to.

2. Instruct the groups that they are going to classify the live insects according to their predator/prey relationships by identifying their appropriate level on the trophic pyramid. After 5-7 minutes, the groups will share where they placed the live insects and why.
    a. If groups have difficulty with this activity, remind them to look at the mouthparts to think about what they eat and what might eat them or to check the game instructions for further assistance. This will help to determine their role regarding being a predator and/or a prey.
3. The live insects should be placed at the following levels, with Level 1 representing the producers:
    a. Level 1 – No Insects (all insects are consumers)
    b. Level 2 – Caterpillar, Darkling Beetle
    c. Level 3 – Carpenter Ant, Cockroach
    d. Level 4 – Praying Mantis, Dragonfly Nymph
4. You can allow for touch time after they have been placed on the levels and the correct placements have been reviewed.
5. Collect the live insects from the groups, making sure to leave the groups' pyramids intact.

Elaboration: This activity shows that changing just one part of an ecosystem causes changes in the other parts, and these changes can have severe consequences.

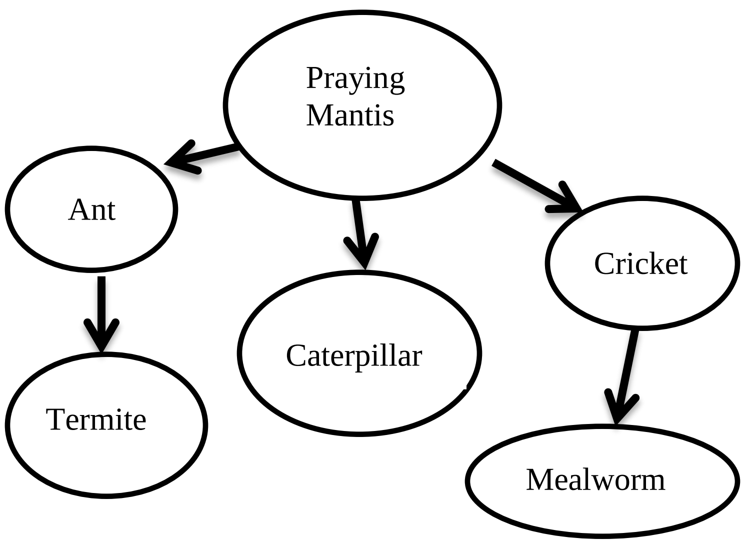
CONNECTING AN ECOSYSTEM

Activity Three:

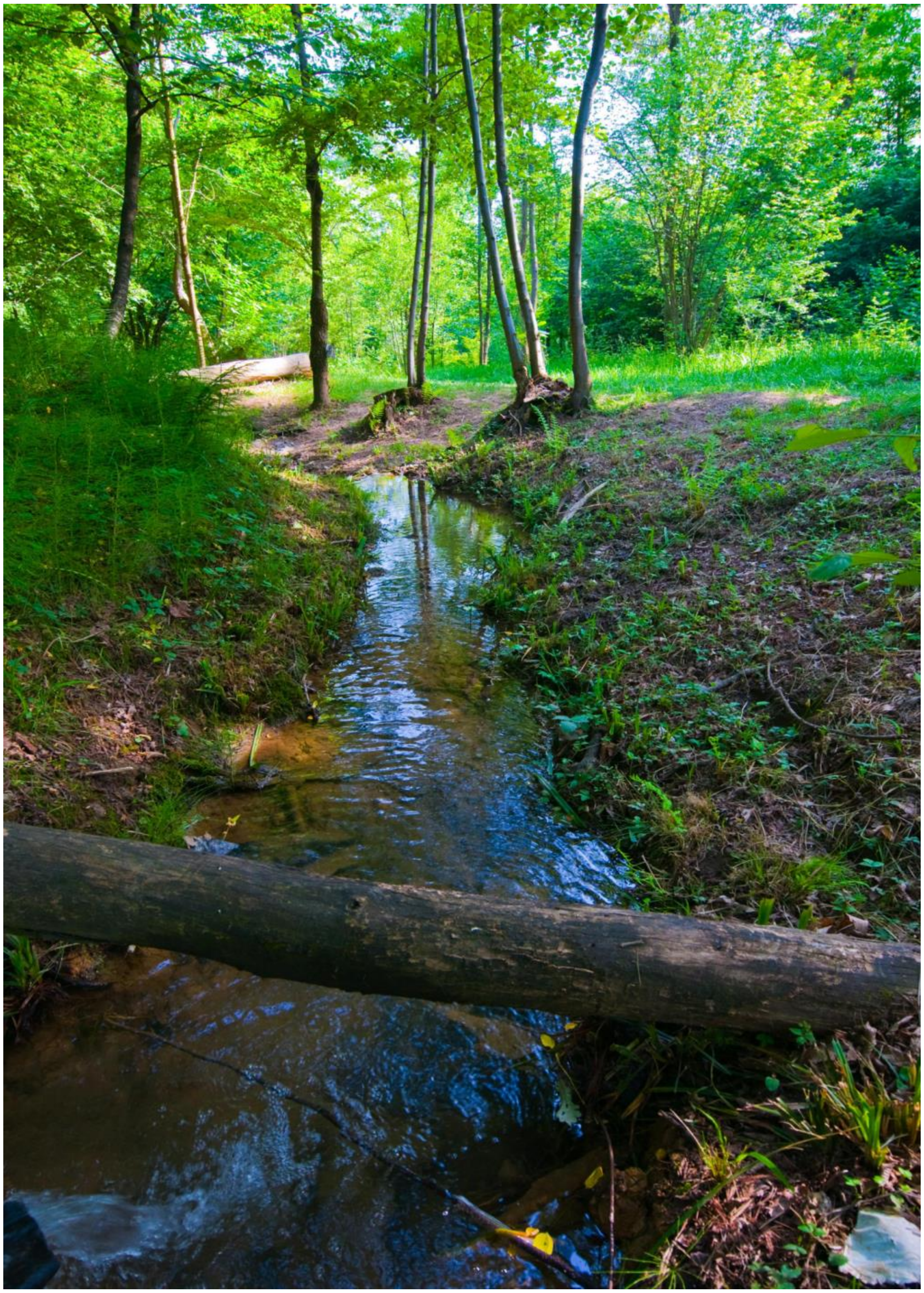
1. Keeping the balance of predators and prey is important because all organisms in an ecosystem are connected.
2. Draw the student's attention back to the Ecosystem Poster from the first lesson. Be sure to attach all the remaining insects that were discussed in this lesson, asking the class where they should go and why.
    a. Praying Mantis: On logs, leaves, or climbing plants.
    b. Carpenter Ant: Near moist, decaying wood or dead leaves
    c. Dragonfly Nymph: In water ways or pools
    d. Darkling Beetle: On or near living and decaying plant matter on the ground
    e. Tobacco Hornworm: On green vegetation
    f. Madagascar Hissing Cockroach: There is no Cockroach because it is already on the poster from a previous session.
3. Tell the class that the poster now includes all the organisms from our ecosystem, yet something is missing. These organisms are not connected yet.
4. Tell the class you are going to focus on the praying mantis for this ecosystem, but that it is just an example of how the animals in an ecosystem are connected.
5. Attach a Velcro/Yarn arrow to the praying mantis, with the round end at the insect and the pointed end still free.

6. Ask the group what insect the praying mantis might eat that is on the poster. To ensure that the arrow can reach all the insects, unwind the yarn from the predator end to reach its prey (the arrowhead). Do not worry if the yarn goes over another animal, or you may want to move the Velcro insects around the poster.
    a. For this lesson, please make these connections from the praying mantis:
        i. Ant
        ii. Caterpillar
        iii. Cricket
    b. Once these connections have been made, ask the class if we can make any connections from these three insects to other animals on the poster:
        i. Ant – termite
        ii. Caterpillar – no
        iii. Cricket – mealworm
            1. See figure
7. Upon completion, show the class how many things are connected in an ecosystem. Review how if we remove a single organism, this changes the entire ecosystem.
8. If you have time, you may also wish to discuss specific scenarios that can change an ecosystem, including:
    a. Clearing the forest for farmland
    b. Spraying pesticides on the field
    c. Chemicals leak into the pond

QUESTIONS & ANSWERS



Appendix H Unifying Activity Ecosystem Poster



Appendix I Student Demographic Questionnaires

STUDENT BASE QUESTIONNAIRE

Insect Outreach Study

Please DO NOT put your name on this paper. All your answers are confidential.

1. Please circle your gender:
   a. Female b. Male

2. Please circle your age:
   a. 9 c. 11 e. 13
   b. 10 d. 12 f. Other (please list) ______

3. Have you ever attended an event about insects or bugs?
   a. Yes b. No c. I don’t know

4. Have you ever held a living insect?
   a. Yes b. No c. I don’t know

5. Do you want to hold a living insect?
   a. Yes b. No c. I don’t know

6. Have you ever learned about insects or bugs at school?
   a. Yes b. No c. I don’t know

7. Have you ever learned about insects or bugs at home?
   a. Yes b. No c. I don’t know

8. Have you ever learned about insects or bugs at a museum?
   a. Yes b. No c. I don’t know

9. Have you ever learned about insects or bugs at a zoo?
   a. Yes b. No c. I don’t know

10. Have you ever learned about insects or bugs at a nature center?
    a. Yes b. No c. I don’t know

11. Have you ever learned about insects or bugs at other activities, like camp or 4-H?
    a. Yes b. No c. I don’t know

12. Do you like to read books about insects?
    a. Yes b. Sometimes c. No

13. Do you like to watch television shows or movies about insects?
    a. Yes b. Sometimes c. No

14. Do you like to go on the internet to learn about insects?
    a. Yes b. Sometimes c. No

STUDENT MID QUESTIONNAIRE

Insect Outreach Study

Please DO NOT put your name on this paper. All your answers are confidential.

1. Since the beginning of the school year, have you attended any insect events <u>OUTSIDE OF SCHOOL</u>?
   a. Yes b. No c. I don't know

2. Did you hold a living insect during the insect lessons?
   a. Yes b. No c. I don't know

3. Since the beginning of the school year, have you held a living insect <u>OUTSIDE OF SCHOOL?</u>
   a. Yes b. No c. I don't know

4. Since the beginning of the school year, have you learned about insects in school?
   a. Yes b. No c. I don't know

5. Since the beginning of the school year, have you learned about insects at home?
   a. Yes b. No c. I don't know

6. Since the beginning of the school year, have you learned about insects at a museum?
   a. Yes b. No c. I don't know

7. Since the beginning of the school year, have you learned about insects at a zoo?
   a. Yes b. No c. I don't know

8. Since the beginning of the school year, have you learned about insects at a nature center?
   a. Yes b. No c. I don't know

9. Since the beginning of the school year, have you learned about insects at other activities, like camp or 4-H?
   a. Yes b. No c. I don't know

10. Since the beginning of the school year, have you read any books about insects?
    a. Yes b. No c. I don't know

11. Since the beginning of the school year, have you watched any television shows or movies about insects?
    a. Yes b. No c. I don't know

12. Since the beginning of the school year, have you gone on the internet to learn about insects?
    a. Yes   b. No   c. I don't know

STUDENT FINAL QUESTIONNAIRE
Insect Outreach Study

Please DO NOT put your name on this paper. All your answers are confidential.

1. Since the beginning of the year, have you attended any insect events OUTSIDE OF SCHOOL?
   a. Yes b. No c. I don't know

2. Did you hold a living insect during the insect lessons?
   a. Yes b. No c. I don't know

3. Since the beginning of the year, have you held a living insect OUTSIDE OF SCHOOL?
   a. Yes b. No c. I don't know

4. Since the beginning of the year, have you learned about insects in school?
   a. Yes b. No c. I don't know

5. Since the beginning of the year, have you learned about insects at home?
   a. Yes b. No c. I don't know

6. Since the beginning of the year, have you learned about insects at a museum?
   a. Yes b. No c. I don't know

7. Since the beginning of the year, have you learned about insects at a zoo?
   a. Yes b. No c. I don't know

8. Since the beginning of the year, have you learned about insects at a nature center?
   a. Yes b. No c. I don't know

9. Since the beginning of the year, have you learned about insects at other activities, like camp or 4-H?
   a. Yes b. No c. I don't know

10. Since the beginning of the year, have you read any books about insects?
    a. Yes b. No c. I don't know

11. Since the beginning of the year, have you watched any television shows or movies about insects?
    a. Yes b. No c. I don't know

12. Since the beginning of the year, have you gone on the internet to learn about insects?
    a. Yes b. No c. I don't know

Appendix J Student Content Knowledge Assessments

STUDENT CONTENT KNOWLEDGE SCALE
LESSON ONE

Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Please read the following questions and all of the possible answers. Choose the one answer that is best for each question.

1. What are the two main types of ecosystems?
   a. Land and Water
   b. Water and Air
   c. Land and Underground
   d. Water and Underground

2. You see an insect on a flower, drinking nectar with a long tube extending from their mouth. Which type of mouthparts does this insect have?
   a. Sponging mouthparts
   b. Siphoning mouthparts
   c. Piercing/Sucking mouthparts
   d. Chewing mouthparts

3. If an insect has wings, how many pairs of wings do they have?
   a. One or two pairs of wings
   b. Two or three pairs of wings
   c. One or three pairs of wings
   d. Three or four pairs of wings

4. Which of the following foods could a butterfly **NOT** eat?
   a. Nectar
   b. Fruit Juice
   c. Soda
   d. Cupcake

5. Which of the following statements is the correct definition of an insect?
   a. An insect has two parts to their body, four legs, and two antennae.
   b. An insect has three parts to their body, six legs, and four antennae.
   c. An insect has two parts to their body, six legs, and four antennae.
   d. An insect has three parts to their body, six legs, and two antennae.

6. Based on the definition of an ecosystem, is a **CITY** an ecosystem?
   a. **NO**, a city is **NOT** an ecosystem. It does not have any living things in it.
   b. **YES,** a city is an ecosystem. It has no man-made buildings only nature in it.
   c. **NO**, a city is **NOT** an ecosystem. It has man-made buildings and no nature in it.
   d. **YES**, a city is an ecosystem. It has a community of living things in it.

7. Match the type of insect mouthparts to the best food choice that it could eat by drawing a line from the insect mouthparts to the food match. Each food choice will only be used once.

MOUTHPARTS	**FOOD**
Siphoning	Orange
Sponging	Garbage
Piercing/Sucking	Seed
Chewing	Nectar

8. Look at the picture below. Based on the definition of an insect, is this a picture of an insect?

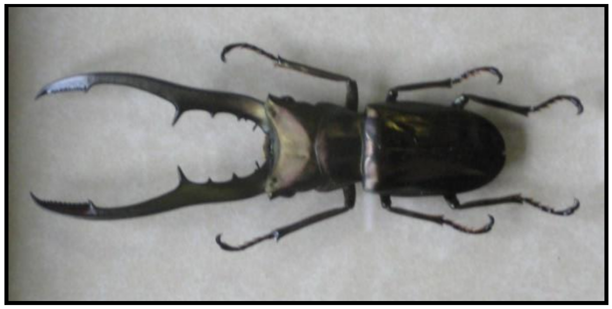
   a. **NO**, this is **NOT** a picture of an insect. It does not have only four pairs of legs, two body segments, and two pairs of antennae.
   b. **YES,** this is a picture of an insect. It has four pairs of legs, four body segments, and a pair of antennae.
   c. **NO,** this is **NOT** a picture of an insect. It has the wrong number of legs, too many body segments, and one pair of antennae.
   d. **YES**, this is a picture of an insect. It has the correct number of legs, body segments, and antennae.

9. TRUE OR FALSE: An ecosystem can be any size, big or small.
   a. True
   c. False

10. Insects that have sponging mouthparts could eat which of the following foods?
   a. Banana
   c. Apple juice
   b. Sandwich
   d. All of the above

11. You get a new insect pet and want to feed it. It has a hard tube attached to its mouth and is usually found living on leaves. What type of insect mouthparts does it have?
   a. Piercing/Sucking mouthparts
   c. Sponging mouthparts
   b. Siphoning mouthparts
   d. Chewing mouthparts

12. Look at the picture below. What type of insect mouthpart is shown in this photo?



a. Chewing mouthparts
b. Siphoning mouthparts
c. Sponging mouthparts
d. Piercing/Sucking mouthparts

STUDENT CONTENT KNOWLEDGE SCALE
LESSON TWO

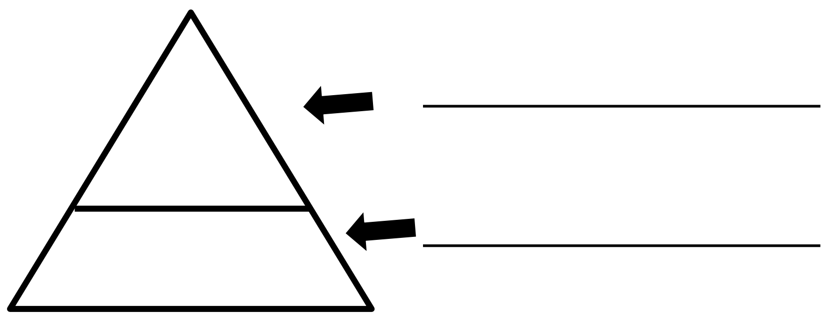
Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Please read the following questions and all of the possible answers. Choose the one answer that is best for each question.

1. Lions are a part of what level on the Trophic Pyramid?
   a. Omnivore c. Carnivore
   b. Herbivore d. Detritivore

2. Below is a picture of the Trophic Pyramid. Please use the words in the **WORD BANK** to label the picture with the names of the two main levels of the pyramid. Not all of the words in the **WORD BANK** will be used.

WORD BANK
Omnivore
Producer
Detritivore
Consumer



3. Which of the following four organisms would be classified as an omnivore?
   a. Flower c. Tiger
   b. Tarantula d. Bear

4. Match the insects below with the correct trophic level by drawing a line from the insect to the trophic level where it belongs. Each trophic level will be used only once.

INSECT	**TROPHIC LEVEL**
Ladybug	Omnivore
Cricket	Herbivore
Milkweed Bug	Carnivore

5. TRUE OR FALSE: Insects that only eat plants can be found at the top of the Trophic Pyramid.
   a. True b. False

6. The omnivore level is a combination of what two trophic levels?
   a. Herbivores and Detritivores
   b. Omnivores and Carnivores
   c. Herbivores and Carnivores
   d. Carnivores and Detritivores

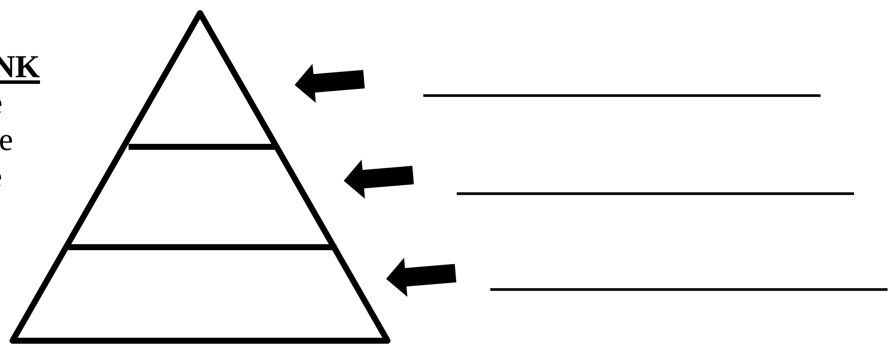
7. You discover a new insect in Indiana and you need to classify it on the Trophic Pyramid. It only eats strawberries. Where would you classify this insect on the Trophic Pyramid?
   a. Omnivore
   b. Detritivore
   c. Carnivore
   d. Herbivore

8. An insect that feeds only on other insects is a part of what trophic level?
   a. Detritivores
   b. Omnivores
   c. Herbivores
   d. Carnivores

9. Put the three different types of consumers in order on the Trophic Pyramid using the words in the **WORD BANK**. Not all of the words in the **WORD BANK** will be used.

WORD BANK

Omnivore
Detritivore
Herbivore
Carnivore



STUDENT CONTENT KNOWLEDGE SCALE
LESSON THREE

Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Please read the following questions and all of the possible answers. Choose the one answer that is best for each question.

1. If you found a fungus growing on a loaf of bread, where would you place it on the Trophic Pyramid?
   a. Producers
   b. Decomposers
   c. Omnivores
   d. Carnivores

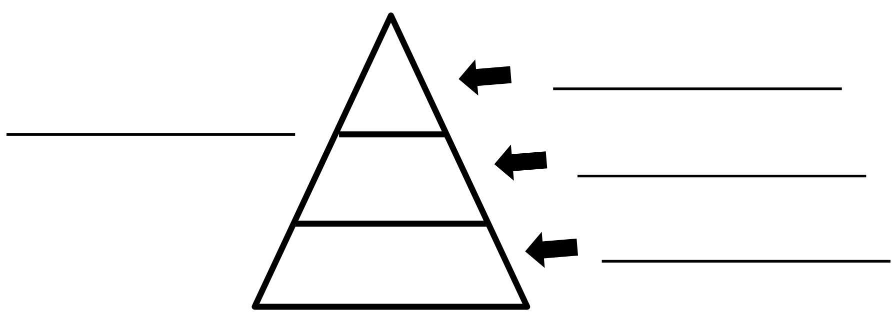
2. Which of the following statements describe one way that decomposers are beneficial in an ecosystem?
   a. They recycle nutrients so that other living things may use them.
   b. They eat other insects that are pests to humans.
   c. They provide the ecosystem with fresh air and oxygen.
   d. They pollinate flowers that turn into fruit or vegetables.

3. TRUE OR FALSE: Decomposers are also known as detritivores.
   a. True
   b. False

4. From the following list, which animal would be found turning waste into foods other animals can use?
   a. Praying mantis
   b. Stag beetle
   c. Mealworm
   d. Shield bug

5. Put the four different types of consumers in order on the Trophic Pyramid using the words in the **WORD BANK**. All of the words in the **WORD BANK** will be used.

WORD BANK
Omnivore
Detritivore
Herbivore
Carnivore



6. Which of the following statements correctly describes what would happen to the wastes in an ecosystem if there were **NO** decomposers living in it?
   a. Wastes would be turned back into food for other organisms.
   b. Wastes would be moved to another ecosystem.
   c. Wastes would pile up and not be food for other organisms.
   d. Wastes would turn into soil for plants.

7. From the following foods, what would a decomposer eat?
   a. A tree
   b. A dead leaf
   c. A cricket
   d. A living plant

8. What is the difference between producers and decomposers?
   a. Producers make their own food while decomposers eat dead plants and animals.
   b. Producers eat other animals while decomposers eat only plants.
   c. Producers eat dead plants and animals while decomposers make their own food.
   d. Producers eat only plants while decomposers eat other animals.

9. You want to find an insect that is a decomposer. Which of the environments below are you **MORE LIKELY** to find a decomposer?
   a. At the top of a tree
   b. Under a log
   c. In a pond
   d. Flying in the air

STUDENT CONTENT KNOWLEDGE SCALE
LESSON FOUR

Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Please read the following questions and all of the possible answers. Choose the one answer that is best for each question.

1. TRUE OR FALSE: When an ecosystem is considered balanced, there are enough prey for each predator to survive.
   a. True   b. False

2. Which of the following statements correctly shows how a Sunflower, Praying mantis, and Beetle are connected to each other?
   a. Beetle → Praying Mantis → Sunflower
   b. Praying Mantis → Beetle → Sunflower
   c. Sunflower → Beetle → Praying Mantis
   d. Beetle → Sunflower → Praying Mantis

3. Match the following insects with their prey by drawing a line from the insect to either the plant or animal prey or both. If they eat both types of prey, draw two lines from the insect to both of the prey. Each prey will be used more than once.

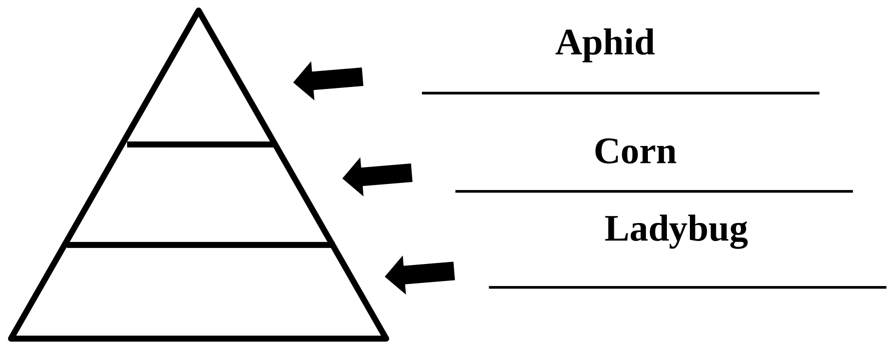
INSECT	**PREY**
Cricket	
Earwig	Plant
Wheel bug	
Walkingstick	
Tiger beetle	Animal
Katydid	

4. How would you place an organism on the appropriate level on the Trophic Pyramid?
   a. Classify it by where it lives and what eats it.
   b. Classify it by what it eats and what eats it.
   c. Classify it by what it eats and how it moves.
   d. Classify it by where it lives and how it moves.

5. Think of a forest ecosystem. What statement best describes what would happen if all the dragonflies in this ecosystem died?
    a. The number of trees would decrease.
    b. The number of bessbugs would increase.
    c. The number of ladybugs would decrease.
    d. The number of mosquitoes would increase.

6. TRUE OR FALSE: A prey is an organism that survives by eating another organism.
    a. True
    b. False

7. Change the names on the Trophic Pyramid below so that it shows the correct placement of predators and prey. Do this by crossing out the name on the line and rewrite the organism name on the correct line for each trophic level.



8. Why should there be more prey in an ecosystem than predators?
    a. To keep the ecosystem stable.
    b. To keep the predators from eating all the prey.
    c. To keep the ecosystem from growing.
    d. To keep the prey from eating all the predators.

9. TRUE OR FALSE: Changing one part of an ecosystem does not change any other part of the ecosystem.
    a. True
    b. False

10. Which of the following statements best describes how a dragonfly is connected to a leaf?
    a. Dragonflies eat leaves and other plants.
    b. Dragonflies live on leaves with other insects.
    c. Dragonflies eat insects that eat leaves.
    d. Dragonflies eat insects that only live on leaves.

11. Which of the following animals is considered a predator?
    a. Earwig
    b. Butterfly
    c. Shield bug
    d. All of the above

12. Which of the following statements best describes what would happen if an organism was removed from an ecosystem?
    a. It will **NOT** change the ecosystem because there is no connection.
    b. It will change the ecosystem because everything is connected.
    c. It will **NOT** change the ecosystem because predators are not connected.
    d. It will change the ecosystem because all prey are connected.

Appendix K Teacher Demographic Questionnaires

TEACHER BASE QUESTIONNAIRE

Insect Outreach Study

Please DO NOT put your name on this paper. All your answers are confidential.

1. Please indicate your gender:
   a. Female
   b. Male

2. Please indicate your age range:
   a. 20-25
   b. 26-30
   c. 31-35
   d. 36-40
   e. 41-45
   f. 46-50
   g. 51-55
   h. 56-60
   i. Other (please list) ___________________

3. Please indicate your ethnicity:
   a. White
   b. Hispanic
   c. African-American
   d. Other

4. Please indicate your highest educational level:
   a. Bachelor's degree
   b. Some graduate work
   c. Master's degree
   d. Doctoral degree
   e. Other (please list) ___________________

5. Please indicate your level of teaching experience:
   a. Less than 1 year
   b. 1-5 years
   c. 6-10 years
   d. 11-15 years
   e. 16-20 years
   f. 21+ years

6. Please indicate your experience teaching at the ELEMENTARY level:
   a. Less than 1 year
   b. 1-5 years
   c. 6-10 years
   d. 11-15 years
   e. 16-20 years
   f. 21+ years

7. Do you specialize in teaching any of the following subjects? (Circle all that apply)
   a. Science
   b. Mathematics
   c. Social Sciences
   d. English/Reading
   e. Arts
   f. Other _________________

8. Have you ever attended an event about insects?
   a. Yes (please indicate name of event _________________________________)
   b. No

9. Have you ever held a living insect?
   a. Yes (please indicate where/when ___________________________________)
   b. No

10. Do you want to hold a living insect?
    a. Yes b. No

11. Do you have any formal training in entomology (university, continuing education, etc)?
    a. Yes (please indicate where/when___________________________________)
    b. No

12. Do you have any informal training in entomology (nature centers, workshops. etc.)?
    a. Yes (please indicate where/when____)
    b. No

13. Have you ever learned about insects at a museum, zoo, nature center, or 4-H event?
    a. Yes (please indicate where/when___________________________________)
    b. No

14. Do you like to read books about insects?
    a. Yes b. No

15. Do you like to watch television shows or movies about insects?
    a. Yes b. No

16. Do you like to go on the internet to learn about insects?
    a. Yes b. No

17. Do you currently teach about insects in your classroom?
    a. Yes (please indicate what/when ____________________________________)
    b. No

18. Have you ever taught about insects?
    a. Yes (please indicate what/when____________________________________)
    b. No

19. Do you want to teach more about insects?
    a. Yes b. No

20. Do you currently teach with live insects?
    a. Yes (please indicate what/when____________________________________)
    b. No

21. Have you ever taught with live insects?
    a. Yes (please indicate what/when_________________________________)
    b. No

22. Do you want to teach with live insects?
    a. Yes
    b. No

23. Would you be interested in learning more about the outreach programs offered in the Department of Entomology at Purdue University?
    a. Yes
    b. No

TEACHER MID QUESTIONNAIRE

Insect Outreach Study

Please DO NOT put your name on this paper. All your answers are confidential.

1. Have you attended any insect events since the beginning of this study?
   a. Yes (please indicate name of event________________________________)
   b. No

2. Have you held a living insect during the insect lessons since the beginning of this study?
   a. Yes (please indicate where/when_________________________________)
   b. No

3. Have you held a living insect <u>outside the insect lessons</u> since the beginning of this study?
   a. Yes (please indicate where/when_________________________________)
   b. No

4. Have you received any formal training in entomology since the beginning of this study (university, continuing education)?
   a. Yes (please indicate where/when_________________________________)
   b. No

5. Have you received an informal training in entomology since the beginning of this study (nature centers, workshops, etc.)?
   a. Yes (please indicate where/when_________________________________)
   b. No

6. Have you learned about insects at a museum, zoo, nature center, or 4-H event since the beginning of this study?
   a. Yes (please indicate where/when_________________________________)
   b. No

7. Since the beginning of this study, have you read any books about insects?
   a. Yes (please indicate what/when__________________________________)
   b. No

8. Since the beginning of this study, have you watched any television shows or movies about insects?
   a. Yes (please indicate what/when__________________________________)
   b. No

9. Since the beginning of this study, have you gone on the internet to learn about insects?
    a. Yes (please indicate what/when___________________________________)
    b. No

10. Since the beginning of this study, have you taught about insects in your classroom outside of the insect lessons?
    a. Yes (please indicate what/when___________________________________)
    b. No

11. Do you want to teach more about insects?
    a. Yes   b. No

12. Since the beginning of this study, have you taught with live insects outside of the insect lessons?
    a. Yes (please indicate what/when___________________________________)
    b. No

13. Do you want to teach with live insects?
    a. Yes   b. No

14. Have you sought out insect-related information since the beginning of this study?
    a. Yes (please indicate what/when___________________________________)
    b. No

15. Have you seen your students seek out insect-related information since the beginning of this study?
    a. Yes (please indicate what/when___________________________________)
    b. No

16. Have your students been asking insect-related questions since the beginning of this study?
    a. Yes (please indicate what/when___________________________________)
    b. No

TEACHER FINAL QUESTIONNAIRE

Insect Outreach Study

Please DO NOT put your name on this paper. All your answers are confidential.

1. Have you attended any insect events since the beginning of this year?
    a. Yes (please indicate name of event________________________________)
    b. No

2. Have you held a living insect during the insect lessons since the beginning of this year?
    a. Yes (please indicate where/when_________________________________)
    b. No

3. Have you held a living insect outside the insect lessons since the beginning of this year?
    a. Yes (please indicate where/when_________________________________)
    b. No

4. Have you received any formal training in entomology since the beginning of this year (university, continuing education)?
    a. Yes (please indicate where/when_________________________________)
    b. No

5. Have you received an informal training in entomology since the beginning of this year (nature centers, workshops, etc.)?
    a. Yes (please indicate where/when_________________________________)
    b. No

6. Have you learned about insects at a museum, zoo, nature center, or 4-H event since the beginning of this year?
    a. Yes (please indicate where/when_________________________________)
    b. No

7. Since the beginning of this year, have you read any books about insects?
    a. Yes (please indicate what/when__________________________________)
    b. No

8. Since the beginning of this year, have you watched any television shows or movies about insects?
    a. Yes (please indicate what/when__________________________________)
    b. No

9. Since the beginning of this year, have you gone on the internet to learn about insects?
   a. Yes (please indicate what/when__________________________________)
   b. No

10. Since the beginning of this year, have you taught about insects in your classroom outside of the insect lessons?
    a. Yes (please indicate what/when__________________________________)
    b. No

11. Do you want to teach more about insects?
    a. Yes   b. No

12. Since the beginning of this year, have you taught with live insects outside of the insect lessons?
    a. Yes (please indicate what/when__________________________________)
    b. No

13. Do you want to teach with live insects?
    a. Yes   b. No

14. Have you sought out insect-related information since the beginning of this year?
    a. Yes (please indicate what/when__________________________________)
    b. No

15. Have you seen your students seek out insect-related information since the beginning of this year?
    a. Yes (please indicate what/when__________________________________)
    b. No

16. Have your students been asking insect-related questions since the beginning of this year?
    a. Yes (please indicate what/when__________________________________)
    b. No

Appendix L Teacher Content Knowledge Assessments

TEACHER CONTENT KNOWLEDGE SCALE
LESSON ONE

Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Each of the questions is followed by four possible answers. Please select the one that is best in each case.

1. You see an insect on a peach. It has a thick tube extending from its mouth with a broad pad at the end, and this pad is sitting in a small pool of peach juice on the surface of the peach. Which type of mouthparts does this insect have?
   a. Siphoning mouthparts
   c. Chewing mouthparts
   b. Sponging mouthparts
   d. Piercing/Sucking mouthparts

2. TRUE OR FALSE: An ecosystem can range from very small environments to very large environments, and is not restricted by size.
   a. True
   b. False

3. If an insect has wings, how many pairs of wings do they have?
   a. Two or three pairs of wings
   c. Three or four pairs of wings
   b. One or three pairs of wings
   d. One or two pairs of wings

4. All of the following statements about ecosystems are true **EXCEPT**:
   a. An ecosystem has organisms that mostly do not interact with the environment.
   b. The two main types of ecosystems are terrestrial and aquatic.
   c. An ecosystem contains a community of living things.
   d. Organisms in an ecosystem interact with other organisms.

5. Which of the following foods would a butterfly **NOT** consume?
   a. Fruit Juice
   c. Coffee
   b. Soda
   d. Nectar

6. Which of the following statements is the correct definition of an insect?
   a. An insect has two body segments, two pairs of legs, and one pair of antennae.
   b. An insect has three body segments, three pairs of legs, and two pairs of antennae.
   c. An insect has two body segments, three pairs of legs, and two pairs of antennae.
   d. An insect has three body segments, three pairs of legs, and one pair of antennae.

7. Match the type of insect to the best food choice it would consume. A food choice may used more than once or not at all.

INSECT	**FOOD CHOICE**
	Orange
House Fly	Corn
Shield Bug	Cardboard
Bessbug	Nectar
Moth	Garbage
	Seed

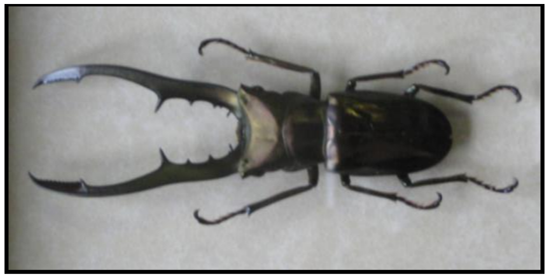
8. Look at the picture below. Based on the definition of an insect, is this a picture of an insect?

   a. **NO,** this is **NOT** a picture of an insect. This animal does not have two body segments, four pairs of legs, and two pairs of antennae.
   b. **YES,** this is a picture of an insect. It has the correct number of legs, body segments, and antennae.
   c. **YES,** this is a picture of an insect. It has three pairs of legs, four body segments, and a pair of antennae.
   d. **NO,** this is **NOT** a picture of an insect. It has the wrong number of legs, too many body segments, and one pair of antennae.

9. Insects with sponging mouthparts are capable of eat which of the following foods?
   a. Apple Juice
   b. Banana
   c. Sandwich
   d. All of the above

10. You are going to keep a new insect in your classroom and need to feed it. Looking at its mouthparts, you see it has a hardened thin tube at its mouth and is usually found living on leaves. What type of mouthparts does this insect have?
    a. Chewing mouthparts
    b. Siphoning mouthparts
    c. Sponging mouthparts
    d. Piercing/Sucking mouthparts

11. Looking at the photo below, what type of insect mouthparts is shown in this photo?



    a. Chewing mouthparts
    b. Sponging mouthparts
    c. Piercing/Sucking mouthparts
    d. Siphoning mouthparts

12. All of the following statements about insect mouthparts are true **<u>EXCEPT</u>**:
    a. Insects mouthparts are highly adapted to their food preferences.
    b. Looking at insect mouthparts can often tell you exactly what food an insect eats.
    c. An insect's mouthparts can be so adapted that they can only eat one type of food.
    d. Identifying an insect's mouthparts can help in classify their role in an ecosystem.

TEACHER CONTENT KNOWLEDGE SCALE
LESSON TWO

Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Each of the questions is followed by four possible answers. Please select the one that is best in each case.

1. Giant water bugs are a part of what level on the Trophic Pyramid?
   a. Detritivore
   b. Carnivore
   c. Herbivore
   d. Omnivore

2. Which of the following four organisms would be classified as an omnivore?
   a. Tarantula
   b. Bear
   c. Tiger
   d. Milkweed Bug

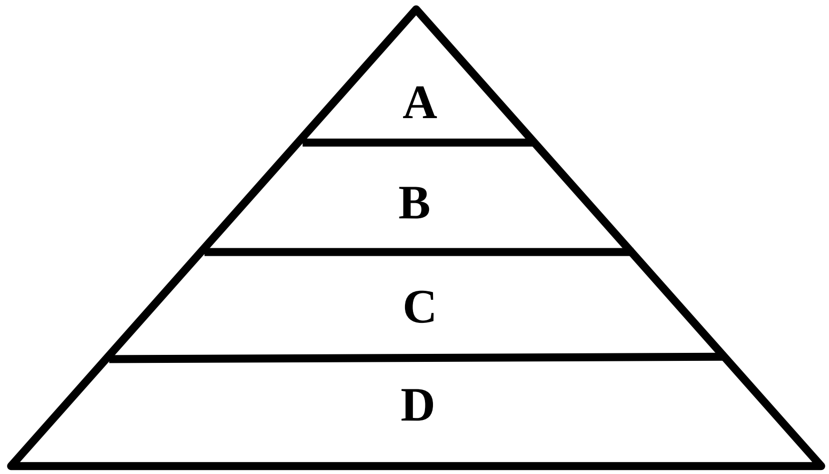
3. All of the following statements about trophic levels are true **EXCEPT**:
   a. All insects are classified as consumers.
   b. Classifying insects on the trophic pyramid helps identify their habitat.
   c. The two main trophic levels are producers and consumers.
   d. Insects are classified based on the items that they consume.

4. What is defined as the position an organism occupies based on their feeding preference?
   a. A trophic pyramid
   b. A classification procedure
   c. A role in the ecosystem
   d. A trophic level

5. The omnivore level is a combination of what two trophic levels?
   a. Herbivores and Detritivores
   b. Detritivores and Carnivores
   c. Carnivores and Detritivores
   d. Herbivores and Carnivores

6. You discover a new insect in Indiana and you need to classify it on the Trophic Pyramid. It consumes only watermelon. Where would you classify this insect on the Trophic Pyramid?
   a. Carnivore
   b. Detritivore
   c. Omnivore
   d. Herbivore

Directions: The group of questions below concerns the Trophic Pyramid. First, study the diagram; then choose the one best answer to each question.



7. The area represented by the D is known as:
   a. The Omnivore Level
   b. The Consumer Level
   c. The Producer Level
   d. The Herbivore Level

8. Which of the following insects would be classified in the B level?
   a. Ladybug
   b. Cricket
   c. Milkweed Bug
   d. Aphid

9. A difference between organisms in the C level and those in the A level is:
   a. Organisms in the C level consume plants; organisms in the A level consume both plants and animals.
   b. Organisms in the C level consume plants; organisms in the A level consume animals.
   c. Organisms in the C level consume animals and plants; organisms in the A level consume animals.
   d. Organisms in the C level produce their own food; organisms in the A level consume animals.

TEACHER CONTENT KNOWLEDGE SCALE
LESSON THREE

Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Each of the questions is followed by four possible answers. Please select the one that is best in each case.

1. All of the following statements about decomposers are true **EXCEPT**:
    a. Decomposers are beneficial to an ecosystem.
    b. Decomposers can be harmful.
    c. Decomposers are a part of the omnivore level.
    d. Decomposers can feed on plants, animals, and wastes.

2. Organisms that consume decomposing organisms are labeled:
    a. Producers
    b. Pollinators
    c. Decomposers
    d. Omnivores

3. From the following list of insects, which would be found recycling nutrients in the ecosystem?
    a. Shield Bug
    b. Grasshopper
    c. Dragonfly
    d. Mealworm

4. Which of the following statements correctly describes a possible effect of removing decomposers from an ecosystem?
    a. Wastes would be recycled back into nutrients.
    b. Wastes would be moved to another ecosystem.
    c. Wastes would remain in the ecosystem.
    d. Wastes would settle into the soil and be used by plants.

5. What is the main difference between producers and decomposers?
    a. Producers create their own food while decomposers feed on decaying organic matter.
    b. Producers feed on plant matter while decomposers feed on animals.
    c. Producers feed on decaying organic matter while decomposers create their own.
    d. Producers create their own food while decomposers eat plant matter.

6. Which of the following statements describe one way that decomposers are beneficial in an ecosystem?
    a. They pollinate flowering plants, such as fruit trees or vegetable plants.
    b. They consume other insects that humans consider pests.
    c. They provide ecosystems with new oxygen.
    d. They recycle nutrients for other organisms in the ecosystem.

7. All of the following statements represent decomposers feeding on appropriate food choices **<u>EXCEPT</u>**:
    a. Bessbugs feeding on grass
    b. Cockroaches feeding on apple slices
    c. Shield Bugs feeding on tree leaves
    d. Flies feeding on mushrooms

8. In which of the following environments are you more likely to locate a decomposer?
    a. Flying in the air
    b. Under a log
    c. At the bottom of a pond
    d. In tree branches

9. In you were searching through a rotting log, what insects are you most likely to find?
    a. Millipedes
    b. Stag Beetles
    c. Dermetids
    d. Woodlice

TEACHER CONTENT KNOWLEDGE SCALE
LESSON FOUR

Please DO NOT put your name on this paper. All your answers are confidential.

Directions: Each of the questions is followed by four possible answers. Please select the one that is best in each case.

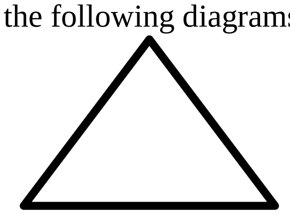
1. Which of the following statements shows a correct relationship between a Sunflower, a Praying mantis, and a Beetle?
   a. Beetle → Sunflower → Praying Mantis
   b. Praying mantis → Beetle → Sunflower
   c. Beetle → Praying Mantis → Sunflower
   d. Sunflower → Beetle → Praying mantis

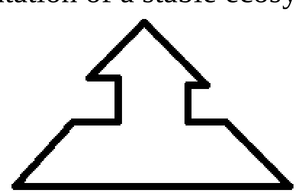
2. Which of the following insects are considered predators?
   a. Shield Bug
   b. Earwig
   c. Butterfly
   d. All of the above

3. Which of the following is least likely to occur when there is unbalance in an ecosystem?
   a. The ecosystem will have too many prey.
   b. The ecosystem will not function properly.
   c. The ecosystem will not have any changes to the environment.
   d. The ecosystem will have too many predators.

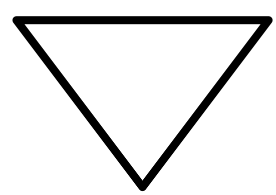
4. An organism that survives by eating other organisms is considered a:
   a. Producer
   b. Predator
   c. Prey
   d. Pest

5. Which of the following diagrams is the best representation of a stable ecosystem?

a. .


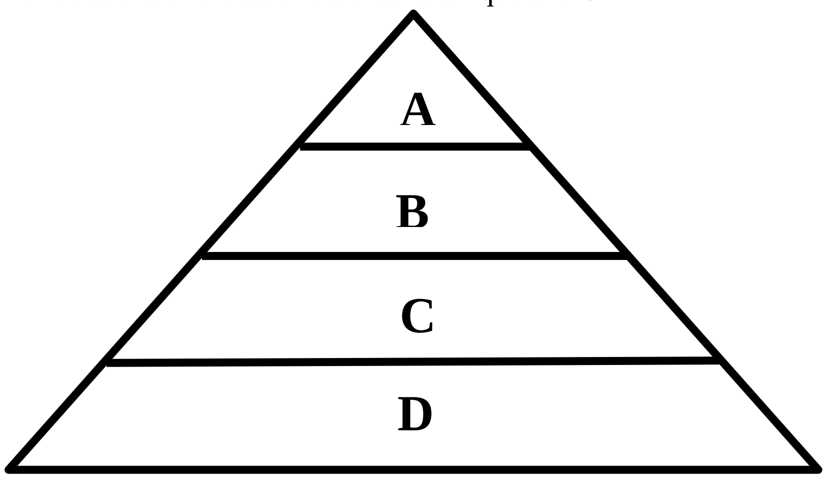
c. .


b.


d. .


6. Think of a forest ecosystem. Which of the following statements best describes what could occur if all the dragonflies died?
   a. The number of bessbugs would increase.
   b. The number of ladybugs would decrease.
   c. The number of mosquitoes would increase.
   d. The number of woodlice would decrease.

Directions: The group of questions below concerns the Trophic Pyramid. First, study the diagram; then choose the one best answer to each question.



7. The areas that contain predators are represented by which letters?
   a. A and B
   b. A, B, and C
   c. B and C
   d. A, B, C, and D

8. Which of the following insects would be classified in the A level?
   a. Deer Fly
   b. Katydid
   c. Tiger Beetle
   d. Robberfly

9. All of the following statements about trophic levels are true **EXCEPT:**
   a. Insects in D level are considered prey.
   b. Insects in B level are considered predators and prey.
   c. Insects in A level are considered higher order carnivores.
   d. Insects in C level are considered predators and prey.

10. Which of the following insects would be classified in the B level?
    a. Earwig
    b. Giant Water Bug
    c. Cricket
    d. Dragonfly

11. TRUE OR FALSE: Changing on part of an ecosystem does not change any other part of the ecosystem.
    a. True
    b. False

12. Which of the following statements best describes the connection between a leaf and a dragonfly?
    a. Dragonflies live on leaves with other insects.
    b. Dragonflies eat insects that only live on leaves.
    c. Dragonflies eat leaves and other plants.
    d. Dragonflies eat insects that eat leaves.

Appendix M Student Modified Intrinsic Motivation Inventory

STUDENT INTEREST IN INSECTS SCALE

Please DO NOT put your name on this paper. All your answers are confidential.

For each of the following statements, please indicate how true it is for you.

1	I put a lot of effort into the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
2	I think the activities with insects are important to do because they can show how to classify organisms as producers, consumers, or decomposers.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
3	I was very relaxed in doing the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
4	I thought the activities with insects were quite enjoyable.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
5	I think the activities with insects are important activities.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
6	The activities with insects were fun to do.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
7	I didn't put much energy into the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
8	I felt very tense while doing the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true

9	I believe the activities with insects could be of some value to me.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
10	I thought the activities with insects were boring activities.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
11	I felt pressured while doing the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
12	I believe doing the activities with insects could be beneficial to me.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
13	I enjoyed doing the activities with insects very much.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
14	I would be willing to do the activities with insects again because it has some value to me.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
15	I didn't try very hard to do well at the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
16	While I was doing the activities with insects, I was thinking about how much I enjoyed it.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
17	I think that doing the activities with insects are useful for understanding different insect roles in an ecosystem.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
18	I would describe the activities with insects as very interesting.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true

19	It was important to me to do well at the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
20	I was anxious while working on the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
21	I think doing the activities with insects could help me to understand the role of organisms in an ecosystem.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
22	The activities with insects did not hold my attention at all.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
23	I did not feel nervous at all while doing the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true
24	I tried very hard on the activities with insects.	1 Not at all True	2	3	4 Somewhat true	5	6	7 Very true

Appendix N Teacher Modified Teaching Self-efficacy Scale

TEACHERS' EFFICACY TEACHING ENTOMOLOGY SCALE

Insect Outreach Study

Directions: This questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for teachers when teaching about and with insects. Please indicate your opinion about each of the statements below ONLY FOR WHEN YOU ARE TEACHING ABOUT AND WITH INSECTS. Your answers are confidential.	Nothing		Very little		Some Influence		Quite A Bit		A Great Deal
1. How much can you do to get through to the most difficult students when teaching entomology lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2. How much can you do to help your students think critically when teaching about and with insects?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3. How much can you do to control disruptive behavior in the classroom during entomology lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4. How much can you do to motivate students who show low interest in school work related to the insect lesson plans?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
5. To what extent can you make your expectations clear about student behavior when teaching about or handling live insects?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6. How much can you do to get students to believe they can do well in the insect lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7. How well can you respond to difficult questions from your students when teaching about and with insects?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
8. How well can you establish routines to keep entomology activities running smoothly?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

9. How much can you do to help your students value learning about entomology?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
10. How much can you gauge student comprehension of what you have taught in the insect lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
11. To what extent can you craft good questions for your students regarding entomology?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
12. How much can you do to foster student creativity when teaching about and with insects?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
13. How much can you do to get children to follow classroom rules during insect lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
14. How much can you do to improve the understanding of a student who is failing during the entomology lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
15. How much can you do to calm a student who is disruptive or noisy when you are teaching the insect lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
16. How well can you establish a classroom management system with each group of students when teaching about and with insects?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
17. How much can you do to adjust your insect lessons to the proper level for individual students?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
18. How much can you use a variety of assessment strategies for the entomology lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
19. How well can you keep a few problem students from ruining an entire insect lesson?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
20. To what extent can you provide an alternative explanation or example when students are confused during an entomology lesson?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
21. How well can you respond to defiant students when you are teaching about and with insects?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

22. How much can you assist families in helping their children do well in the entomology lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
23. How well can you implement alternative strategies in your classroom when teaching about and with insects?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
24. How well can you provide appropriate challenges for very capable students during the entomology lessons?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

VITA

VITA

FAITH WEEKS

EDUCATION

Purdue University, West Lafayette, IN
Ph.D. in Entomology
Area of Concentration: Insect Education & Outreach **Expected May 2015**
Dissertation: "Comparing Educational Delivery Methods for their Impact on Student and Teacher Knowledge of and Interest in Entomology"
Advisor: Dr. Christian Y. Oseto

Southern Connecticut State University, New Haven, CT
M.S. in Environmental Education **2009**
Thesis: "Ew, That's Icky: Assessing Children's Attitudes Towards the Insects of Connecticut"
Advisor: Dr. Susan Cusato

Elmira College, Elmira, NY
B.A. in Psychology **2005**
Area of Concentration: Social Psychology
Minor: Women's Studies
Graduated Magna Cum Laude

TEACHING AND MENTORING EXPERIENCE

Purdue University, West Lafayette, IN
Afghan Junior Faculty Development Program Mentor **Spring 2014**
As a part of the International Programs in Agriculture, I work with Dr. Chris Oseto to train four Afghani faculty members from the Purdue-Herat University Agricultural Partnership over a period of 9 weeks. The goals of the program are to broaden their skills as teachers, learn about the US higher education system, and increase our understanding of their culture. We educate them in best teaching practices, learning theories, establish rapport with students, group activities, and active learning

strategies, and we learn more about their teaching strategies and cultural differences. Participants are also observing my teaching style and techniques in my ENTM 207 laboratory course, where they note different strategies and student-teacher relationships as well as work with undergraduate students to complete entomology activities.

Discovery Park Undergraduate Research Internship program mentor **Fall 2013 – present**

Mentor two undergraduate students in the interdisciplinary research environment of the GK-12 program (discussed below) in a research team with the Program Director, Dr. Jon Harbor. To conduct this research, I train the undergraduates in qualitative research methods, inter-rater reliability measures, and publication writing to analyze weekly journals from program participants to determine its effectiveness in meeting graduate student learning outcomes.

Teaching Assistant – ENTM 207 General Entomology Laboratory **Fall 2012 - present**

Head teaching assistant for the laboratory course, in addition to teaching one laboratory through hands-on activities, class discussions, and presentations. Review with students and grade quizzes and laboratory practical exams, and host office hours for additional guidance. Mentor new teaching assistants in managing student behavior issues, effective teaching techniques, and best methods for communicating with students. Use early feedback from students mid-semester to modify lab teaching.

Program Coordinator for the Sustainable GK-12 Program **Spring 2010 – present**

The GK-12 program works with graduate and post-doctoral students from any discipline to enhance their communication and teaching skills by volunteering in a local middle school for a semester. Participants work closely with their paired teacher to create a lesson based on their research that also meets the needs of the curriculum. Once funded by the National Science Foundation, this is the sustainable continuation of the program that provides one fellowship to support the program coordinator. Duties include recruiting participants each semester by creating presentations and brochures, collaborating with the lead teacher at the middle school to pair participants with volunteer teachers and participant issues, aid participants in applying for grants to fund their classroom lesson, revise participant lesson plans, and develop & lead monthly meetings to educate participants in research-based pedagogy, inquiry-based lesson planning, and state standards.

Guest Lecturer – AGR 117
Orientation to Entomology at Purdue **Each Fall 2010 - 2014**
Present on the outreach efforts of the department, including annual events, key faculty, and how to get involved to incoming freshman in the Department of Entomology, using multimedia and hands-on examples.

Teaching Assistant – ENTM 460
Aquatic Entomology **Spring 2010**
Prepare presentations, quizzes, and tests for lecture course and teach the laboratory portion of the class. Gather aquatic insect specimens for study, create laboratory exercises in support of lecture topics, and construct specimens for laboratory practical exams. Grade all assignments, quizzes, and tests.

Elmira College, Elmira, NY
Teaching Assistant – PSY 453
Social Psychology **Fall 2004**
Assist in preparing lecture materials, hold weekly review sessions, and grade all tests and assignments. Develop and administer class activities and assignments.

PUBLICATIONS AND PRESENTATIONS

"Comparing Outreach Methods for their Effect on Learning Environmental Education"
Paper presented at the Annual Conference of the North American Association for Environmental Education, Ottawa, Canada **October 2014**

"Outcomes of Three Delivery Methods in Entomological Outreach for Classroom Teachers"
Paper presented at the Annual Research Symposium of the North American Association for Environmental Education, Ottawa, Canada **October 2014**

Weeks, F., & Harbor, J. (**2014**). Assessing the impact of a K-12 engagement program on graduate learning outcomes for communicating with diverse audiences, pedagogy, and community engagement. *International Journal for the Scholarship of Teaching and Learning, 8*(2), Article 16.

"Comparing Informal Outreach Methods for their Effect on Student Learning and Interest in Entomology"
Paper presented at the Annual Meeting of the American Educational Research Association, Philadelphia, PA **April 2014**

"Outcomes of Three Delivery Methods in Entomological Outreach for Classroom Teachers"
Poster presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA **April 2013**

"Outcomes of Insect Outreach Delivery Methods for Classroom Teachers"
Paper presented at the Ohio Valley Entomological Association Annual Forum, Cincinnati, OH **October 2012**

"The Impact of a Sustainable GK-12 Program on Graduate Learning: Integrating Graduate Students and their Research into K-12 Classrooms"
Poster presented at the National Outreach Scholarship Conference, University of Alabama, Tuscaloosa, AL **September 2012**

"Evaluating Methods in Entomological Outreach for Impact on Classroom Teachers"
Paper presented at the National Outreach Scholarship Conference, University of Alabama, Tuscaloosa, AL **September 2012**

"Integrating Graduate Students and their Research into K-12 Classrooms: From Well-funded Innovation to Affordable Implementation"
Poster presented at the Transforming Education Conference, Purdue University, West Lafayette, IN **October 2011**

"Evaluating Instructional Delivery Methods in Entomological Outreach"
Poster presented at the National Outreach Scholarship Conference, Michigan State University, East Lansing, MI **October 2011**

"Ew, That's Icky: Assessing children's attitudes towards the insects of Connecticut"
Paper presented at the Ohio Valley Entomological Association Annual Forum, Cincinnati, OH **November 2009**

UNIVERSITY SERVICE

Purdue University, West Lafayette, IN
Office of Student Rights and Responsibilities
Community Standards Board **Fall 2012 – present**
Adjudicate student conduct violation cases on campus as a panel of three students and two faculty or staff.

Department of Entomology Outreach Events **Fall 2009 – present**
Create & teach over 90 outreach events, ranging from classroom visits to community-wide events, including:

- Talks & Tours program: Develop & teach educational and entertaining programming for all audience groups about requested entomological and biological topics, including ecology, insect behavior, and environmental issues. Schools, learning centers, and meetings ask for entomological presentations to support their curriculum, programming, or purpose.
- Insectaganza: Develop & teach at an annual event for regional 5th grade classrooms to enhance their science learning with entomology, including grasshopper dissection, insect theater, insect bingo, petting zoo, and forensic science. Supervise undergraduate volunteers at the events to help teach up to 1,000 students about entomological and biological concepts.
- Community Events: Create, present and teach at annual events to educate the public about insects, including the Indiana State Fair, where the department hosts a Bug Day with live specimens, insect products, and cockroach races. Another large event, Bug Bowl, teaches 30,000 annually about insects through a petting zoo, cockroach races, cricket spitting, insect art contest, and insect crafts/games.

Non-Departmental Outreach **Fall 2009 – present**

Collaborate with other departments, including Chemistry, Youth Development and Agricultural Education, and Engineering, to create and teach outreach events on campus, including for the American Chemical Society's National Chemistry Week, 4-H camps, and Innovation to Reality After-school program for the Women in Engineering program.

University-wide Outreach Events **Fall 2009 – present**

Assist with larger outreach events on campus, including judging the Indiana Regional Science Fair for grades 3-12 to determine finalists for the state level competition, judging prepared speeches in the Indiana Regional Academic Decathlon, and Next Generation Scholars Fair, a reverse science fair for middle school students to prepare them for their own science fair experiments.

PROFESSIONAL EXPERIENCE

Purdue University, West Lafayette, IN

Advanced Graduate Teacher Certificate **Spring 2015**

A certificate program offered by the Center for Instructional Excellence to enhance my teaching experiences, including attending a series of instructional development workshops, mentoring other teaching assistants, classroom observations of other teaching assistants and faculty, service learning projects, volunteer instruction in the community, preparing a teaching philosophy, and feedback on my teaching techniques.

American Educational Research Association
2015 Annual Meeting Reviewer **August 2014**

Review proposal submissions for the 2015 Annual Meeting of the American Educational Research Association conference in Chicago, Illinois in April 2015. Subject matter categories include Learning and Instruction: Science group and six Special Interest Groups (Classroom Assessment, Doctoral Education Across the Disciplines, Environmental Education, Informal Learning Environment Research, Out-of-School Time, and Science Teaching and Learning). A total of 43 paper proposals and 4 session proposals were reviewed for the annual meeting, including providing author feedback on their research and writing.

North American Association for Environmental Education
2014 Annual Meeting Reviewer **April 2014**

Review proposal submissions for two strands of the conference; Greening K-12 and Higher Education, and Connecting People to Nature for the 2014 Annual Meeting of the North American Association for Environmental Education to be held in Ottawa, Canada in October 2014. A total of 24 paper abstracts were reviewed for the annual meeting, including providing author feedback on their research and writing.

Department of Entomology
Curriculum and Student Relations Committee **January 2014 – present**

Represent the graduate students for this committee by providing feedback and student perspective on undergraduate learning. Review, revise, and recommend courses for the undergraduate curriculum, including meeting university standards and incorporating learning objectives and outcomes.

Department of Entomology
Graduate Curriculum Committee **August 2013 - present**

Represent the graduate students for this committee by providing student perspective, feedback, and suggestions on graduate learning. Review, revise, and recommend courses for the graduate curriculum, including the creation of core courses and meeting the career needs of today's graduates. Serve as the liaison between faculty and graduate students through the Entomological Graduate Organization (EGO).

Co-founder and Member of Discipline-Based Education
Research for Graduate Students (DBER-GS) **January 2013 – present**

A graduate student group comprised of DBER scholars throughout Purdue University, including engineering, chemistry, biology, earth sciences, agriculture, and physics. Goals are to create a support group for such scholars, share research, career opportunities, and collaborate on new DBER research projects, including conducting a study of DBER scholars for their perspectives of the interdisciplinary field.

College of Agriculture
Graduate Student Advisory Council **January 2012 – present**

Represent the Department of Entomology in a collaborative effort to enhance the graduate experience by engaging faculty, staff, and students to better the college, including mentoring, career education, and professional development. The council created, administered, and analyze a survey to determine graduate student perspectives on the effectiveness of their mentor-mentee relationship with their advisor, the college's connection to industry, assisting in career placement and options, and the college's offerings for workshops, symposiums, and social events.

President, Entomological Graduate Organization (EGO) **January 2011 – May 2014**

Hold monthly meetings to discuss key issues with graduate students and act as a liaison between graduate students and the department head. Instituted a Graduate Spotlight to highlight students on the department's website each month, obtained funding and lead a trip to New Orleans in Spring 2013 to visit the Audubon Insectarium & collaborate with local entomologists.

Participant in the Sustainable GK-12 Program **Spring 2010**

Worked with a science teacher at a local middle school for one day per week over the course of one semester to develop and teach a lesson about my research to enhance their curriculum in an effort to meet state standards. Gained insight into public education, the needs of teachers, and communicating with diverse audiences.

GRAD 590 Preparing Future Faculty **Spring 2010**

Participate in a course to increase my understanding of the responsibilities of faculty members, the tenure system, and how to develop a research statement, teaching philosophy, and curriculum vitae.

Department of Entomology Outreach Committee **August 2009 – present**

Plan and execute outreach programming and events in the department, collaborate with faculty & staff to develop new outreach efforts and organize larger activities, and collaborate with volunteers to improve outreach in the department. Created, updated, and lead an Insectaganza activity, Insectingo, where roughly 600 5th grade students answer questions on insects and related arthropods on a bingo-like card to gain the opportunity to play insect-based games like dung beetle ball rolling race.

AWARDS

Bisland Strategic Initiatives Fellowship, **Purdue University** January 2010 – present

- Funding to be the Program Coordinator of the GK-12 program, renewed each year based on the success of the program, meeting graduate learning outcomes, and recommendation of the program director, Dr. Jon Harbor.

Purdue Graduate Student Government Travel Grant, **Purdue University** Spring 2015

2014 Outstanding Service by a Student, Department of Entomology, **Purdue University** December 2014

Community Service/Service Learning Project Grant, **Purdue University** Fall 2014

Purdue Graduate Student Government Travel Grant, **Purdue University** Fall 2014

Department of Entomology Graduate Student Spotlight, **Purdue University** April 2014
(http://www.entm.purdue.edu/EGO/spotlight_archive/weeks.html)

Purdue Graduate Student Government Travel Grant, **Purdue University** Spring 2014

Robert O. and Norma Y. Williams Pest Control Conference Award, Department of Entomology, **Purdue University** Fall 2013

2012 Outstanding Service by a Student, Department of Entomology, **Purdue University** December 2012

National Pest Management Association Scholarship, Department of Entomology, **Purdue University** Fall 2012

Community Service/Service Learning Project Grant, **Purdue University** Spring 2010

Community Service/Service Learning Project Grant, **Purdue University** Fall 2010

Third Place, Master's Degree Competition, 2009 Annual Forum, **Ohio Valley Entomological Association** Fall 2009

MEMBERSHIPS

American Educational Research Association
North American Association for Environmental Education
Ohio Valley Entomological Association