Development and Implementation of a Bed Bug IPM Enrichment Curriculum, Part I

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As concerns about bed bug sightings began to increase and schools began to report bed bug introductions, an expert group convened by the Environmental Protection Agency recommended development of curricula to teach young students about bed bug biology and management. The Bed Bugs and Book Bags curriculum is our response to this recommendation. This third- through fifth-grade curriculum was developed using a six-step process, and has been implemented by health educators, teachers, and the pest management industry within and outside of the United States. The curriculum consists of 10 lessons correlated with state health educational standards and is specifically designed to educate teachers and students about bed bugs. In pilot testing of various groups including teachers, students, custodial staff at rescue missions, and pest management professionals, teacher and student groups had the highest increase in knowledge gain after being introduced to the curriculum. The curriculum is available online at http://duval.ifas.ufl.edu/Bed_Bugs.shtml. Based on self-reporting, it has a potential impact of reaching approximately 40,000 people across the United States, Canada, and Saudi Arabia. The Bed Bugs and Book Bags curriculum placed first as a learning module with the Florida Association for County Agriculture Agents and was a regional finalist with the National Association for County Agriculture Agents. This demonstrates its potential to be used as a model for educational bed bug material for higher grades within and outside academia.

Bed Bugs in Schools: A “Teachable Moment”

Bed bugs present a challenge for the adoption and implementation of school Integrated Pest Management (IPM) programs nationwide. Schools are prime opportunistic sites for bed bug introductions and re-introductions. Communities with high numbers of bed bug infestations have frequent bed bug introductions within schools (Green and Gouge 2009). Because bed bugs are not easily detected, they can be transported from infested homes to school on a child’s belongings, notably book bags. Some schools have temporarily banned backpacks and lunch boxes after bed bug sightings in the classroom. The fear is that in schools bed bugs can be transferred from student belongings to surroundings, and potentially from surroundings to teachers and staff.

Schools that have encountered bed bugs resort to pesticides as their primary management strategy. In some cases, the improper use of pesticides leads to bigger problems, such as pesticide-related illnesses (McFarland 2010, Owens 2003, Alarcon et al. 2005). Fortunately, there are available online protocols on how schools can mitigate bed bugs using IPM
Fig. 2. Percent knowledge gain of subject area by audience. With exception of the mixed group in the prevention and treatment data, each group had a significant knowledge gain in each subject area, biology, medical aspects, and prevention and treatment.

(Miller 2012). An inherent challenge is utilizing this teachable moment to educate the public about the potential for IPM to reduce the incidence of transferring bed bugs from homes to schools.

Curricula are viewed as the link between schools and society, and are useful when they are viewed as having merit and value (Welch 1969). The comprehensive learning plans discussed here involve creating guided activities that students can implement within or outside their school environment. These activities translate into learning experiences based on predetermined goals (Frey 2011, Kerr 1968). Any successful curriculum takes into account external standards and local goals, and shapes a plan that delivers effective teaching and learning (Wiggins and McTighe 2005).

At the 2009 National Bed Bug Summit in Arlington, Virginia, the EPA recommended the development of a bed bug education curriculum for children (ENBBS 2009). A focus group of public school educators from the Duval County Public School District (Duval County, FL) determined that elementary school students were high-priority targets for bed bug curricula. According to Piaget’s theory of cognitive development, children between age seven and 12 go through the “concrete operational stage” of cognitive development, in which they can more competently draw conclusions from interrelationships through logical reasoning, and they learn by interacting with family and the wider social world (Goswami 2001, Santrock 2008). Also, at this stage, their socio-emotional processing increases. As relationships with other people are formed, children at this age are more likely to be environmentally aware, and they can be effective at influencing their parents to adopt positive environmental behaviors (Leeming et al. 1997, Santrock 2008).

These research observations show that third through fifth graders can be naturally inquisitive learners who tend to share what they learn in the classroom with their parents and relatives, and who can thereby influence parents and relatives concerning issues such as bed bug awareness. Since bed bugs are ectoparasites that children can bring to school on their belongings, the educator focus groups decided that the educational curriculum should be tailored for health education where concepts such as hygiene and health, critical thinking, comprehension, environmental literacy, communication, creativity, social development, technology, and self-concept could be covered.

True learning happens when a student develops higher-order thinking skills, rather than mere memorization of facts for later regurgitation on a test or quiz (Wiggins and McTighe 2005). This certainly applies to learning about bed bugs. In order to determine whether students have correctly understood the material taught in the Bed Bugs and Book Bags curriculum, they need to demonstrate knowledge, and application of this knowledge, in accordance with state content standards (Schmoker 2002). Therefore, one of the main characteristics of a successful curriculum is how well content, pedagogy, and assessment are aligned with state standards (Schmoker 2002, Aldrich 2007, Marzano 2003).

The goals of this project were to develop a bed bug curriculum that would meet state educational standards for third through fifth
Curriculum Development

After input from the teacher focus group, a curriculum outline was developed according to the six-step process advocated by Kern et al. (2009). Lessons and activities were written between April and June 2011, were modified through April 2012, pilot tested through 2013, and reviewed through a follow-up survey in 2014.

Step 1: Identification and analysis of a need or problem that could be addressed via curricula. In early 2011, the University of Florida Duval County Extension office began receiving requests from public schools for information on school IPM policies about bed bugs. Jacksonville is a rapidly growing urban center in the state of Florida with a U.S. Census Bureau population estimate of 827,908, of which approximately 33,000 are third through fifth graders. The Duval County Health Department also experienced increases in the number of calls concerning bed bug sightings in elementary schools at this time.

Step 2: Needs assessment of the targeted group that would benefit from the curriculum. To meet the bed bug educational needs of the community, the Jacksonville Bed Bug Task Force (JBBTF) was assembled. The task force included 24 members representing the University of Florida, Duval County Public Schools, Duval County Health Department, Duval County Extension Office, Florida Department of Agriculture and Consumer Services, City of Jacksonville, ElderSource, Housing and Urban Development (HUD), Florida Pest Management Association (FPMA), and additional local pest management professionals. The JBBTF met to consider how an educational intervention for third through fifth graders would aid in reduction of bed bug re-introductions and stimulate overall bed bug awareness. The task force set a list of objectives that included bed bug awareness facts important in educating students and teachers.

Step 3: Setting goals and objectives. One of the primary goals of the JBBTF was to increase student awareness of bed bugs so that knowledge could be passed to the child's community (parents, neighbors, friends, and relatives). This was accomplished through the health curriculum developed by the education committee of the JBBTF.

Step 4: Development of educational strategies to meet outlined goals and objectives. Content and methods were outlined according to the 4-H experiential learning model. The 4-H experiential learning model utilizes the five-step paradigm of experiencing, sharing, processing, generalizing, and applying the concepts learned (Deim 2001). Based on the teacher focus group list of needs, the curriculum lesson activities included nine learning concepts: hygiene and health, critical thinking, critical understanding, environmental understanding, communication, creativity, social development, technology, and self-concept. The Florida Department of Education’s Next Generation Sunshine State Health Standards and Benchmarks for third through fifth grade (FDOE 2012) were correlated with each of the lesson activities.

Step 5: Implementation. Curriculum implementation involved measuring knowledge transfer from the curriculum into the community via pilot testing.
IRB approval (UF IRB # 2011-U-1267) was obtained for this curriculum and its supporting materials to be delivered to educators, students, and parents. Two phases were involved in pilot testing the curriculum:

**Phase one: Pilot testing the bed bug curriculum in Duval County, Florida.** The first pilot test was conducted in third- through fifth-grade classes in Duval County. This involved onsite teacher instruction and in-service training for extension agents and 4-H personnel to facilitate implementation of material in Duval County. Data from pre-tests and post-tests were collected from these educators to determine how and when they would use the curriculum in the classroom. Pre-test and post-test questions were then divided into biology, medical, and prevention and detection categories to allow accessing the knowledge in these areas.

After the teachers used the curriculum, they were asked to evaluate it on appropriateness for age group, encouragement of experiential learning, and both potential and verified material retention among students.

**Phase two: Pilot testing bed bug curriculum on a national and global level.** The second phase of this project involved presenting this curriculum through an online learning module for educators. After successful completion of the module (assessed via passing an online quiz with a minimum score of 80%) educators had access to the downloadable curriculum, live presentations of the bed bug biology module, and demonstrations of the curriculum. Live presentations involved giving a bed bug knowledge pre-test, conducting a presentation on concepts within the curriculum, and a post-test to evaluate knowledge gain. Knowledge gain was compared among various participants, including pest management professionals (PMPs), Naval Facilities Engineering Command (NAVFAC), 4-H Agents, Master Gardeners, Duval County Public School Teachers, fifth-grade students, college students, and a mixed group of apartment managers, housekeepers, janitorial staff, and transitional workers with low literacy levels. The results were again divided into biological, medical, and prevention and detection categories to allow assessment of the knowledge in each area. To measure knowledge gain for each group, paired *t*-tests were performed. To compare differences among group scores, a one-way ANOVA was used, while means separation was determined by LSD post-hoc tests (JMP software version 9.0.2 SAS Institute Inc. 2012).

**Step 6: Curriculum evaluation.** Knowledge gain data obtained from different societal groups were used to formatively evaluate the curriculum. This involved identifying areas of improvement and recommending specific suggestions on how to improve the curriculum for these groups in society. The curriculum was also evaluated for reading ease appropriate to specified grade levels.

The following formula was used to calculate the reading ease score: $206.835 - (1.015 \times \text{ASL}) - (84.6 \times \text{ASW})$ where ASL is the average sentence length (number of words/number of sentences) and ASW is the average number syllables per word (number of syllables divided by number of words) (Kincaid et al. 1975). The Flesch-Kincaid Grade Level test was calculated using the following equation: $(0.39 \times \text{ASL}) + (11.8 \times \text{ASW}) - 15.59$ (Kincaid et al. 1975).

**Results**

The completed curriculum is a 103-page document comprising a teachers’ guide to bed bug information, three learning topics with ten lesson plans, and appendices that include the Next Generation Educational Standards and Benchmarks (for third, fourth, and fifth graders) and a teacher feedback form. The teachers’ guide gives an overview of the biology and medical significance of bed bugs, along with information about detection and prevention techniques. The guide is organized by topic sections for ease of reference as each lesson is taught.

Each lesson activity is designed based on a 4-H Experiential Learning Model template: a key concept, objectives, activity introduction with questions, and “Let’s Do,” “Let’s Reflect,” and “Let’s Apply” sections. Each lesson has one or more of the following hands-on activities: crosswords, quizzes, vocabulary, teacher’s guide, and a field trip scenario.

**Table 1. Reading ease and levels for students associated with various activities in the Bed Bugs and Book Bags curriculum based on Flesch-Kincaid model.**

| Curriculum Activities | Flesch Reading Ease (%) | Flesch-Kincaid Grade Level |
|-----------------------|-------------------------|-----------------------------|
| Students              |                         |                             |
| Bed Bug Scavenger Hunt| 100                     | 1                           |
| Student Quiz          | 92                      | 3                           |
| Describe the Culprit  | 88                      | 3                           |
| Feeding Crossword     | 77                      | 5                           |
| Feeding Facts         | 75                      | 6                           |
| Field trip Scenario   | 77                      | 6                           |
| Bed Bug Old Maid Game | 65                      | 7                           |
| Overall Average       | 82                      | 4.4                         |
| Teachers              |                         |                             |
| Teacher’s Guide       | 67                      | 7                           |
| Educator’s Quiz       | 55                      | 8                           |
| Hygiene and Health    | 73                      | 6                           |
| Eat Like a Bug        | 80                      | 6                           |
| Bed Bug Barracks & Beyond | 70                 | 7                           |
| Bed Bug Biology       | 69                      | 8                           |
| Bed Bug Game          | 65                      | 8                           |
| Starring Bed Bugs     | 69                      | 7                           |
| Feelings Finder       | 73                      | 7                           |
| Healthy Hand Healthy Home | 78                    | 7                           |
| It’s Getting Hot in Here! | 77                     | 6                           |
| High Tech Bed Bugs    | 65                      | 8                           |
| Overall Average       | 70.1                    | 7.6                         |
find-a-word, matching and mystery games, short compositions, scavenger hunts, drawing and annotating, dances, and card games. Included with each lesson is a preparation box detailing the learning concepts for that particular lesson, the grade level to which the lesson applies, the recommended setting for that lesson, the recommended time allotment, the entomology skill(s) that will be learned, the life skill(s) that will be learned, the educational standards applicable to that lesson, the materials needed for that lesson, and the section of the Bed Bug Teacher’s Guide corresponding to that lesson.

When the curriculum was evaluated for ease of reading and grade level based on the Flesch-Kincaid scale, heavy-text student activities were ranked as easy to read, obtaining a reading ease average score of 82 out of 100%. The average curriculum activity was determined to be at a fourth-grade level, and the majority of heavy-reading activities in this curriculum were within the third- to fifth-grade level based on the Flesch-Kincaid Grade Level Scale (Table 1).

For the teacher section of the curriculum, the overall ease of reading was on average 70 out of 100% based on the Flesch-Kincaid Scale. The teacher sections of the lessons and the teacher guide ranked at a seventh-grade or higher reading level (Table 1).

Summary
Key aspects of the curriculum development process included adherence to the six-step process advocated by Kern et al. (2009). Creation of the 103-page curriculum document was based on identification of an educational need, identification of target audiences, and a process of matching educational objectives with curriculum development strategies. Pilot testing required obtaining IRB approval as the curriculum was introduced into third- through fifth-grade classrooms. Formative evaluation of the curriculum included assessment of how easily the different target audiences could read and comprehend the written information provided.

Curriculum implementation took place from 2012 through 2014, and included two phases: training of educators to implement the curriculum, and evaluation of efficacy of the curriculum following implementation. Results and discussion of these two phases will be the subject of Part II of this article (to be published in the Fall 2016 issue of American Entomologist, Volume 62, Number 3).

The curriculum and online training module are available online at http://duval.ifas.ufl.edu/Bed_Bugs.shtml.

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