

Title: Text versus images as tools when solving conceptual problems

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Discipline: Biology

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Course Names: General Biology, Organismal Biology

Course Descriptions: Lee Baines included our lesson study in one lecture section of General Biology, a class of ~60 primarily freshmen students. General Biology (Bio 105) is an overview of biology (evolution, molecular biology, ecology) geared toward freshmen in the biology major. Barrett Klein included our lesson study in one lecture section of Organismal Biology, a class of ~70 primarily sophomore students. Organismal Biology (Bio 203) is a core course in the biology major with Bio 105 serving as a prerequisite.

Abstract: What tools best aid a student when solving a conceptual problem? We hypothesized that when presented with extra text and an image, each giving information how to solve a problem, undergraduate students would fare better than students given extra text or image alone, and certainly better than a control given neither extra text nor image. The general problem: how does a honey bee communicate to her nest mates the direction from their nest to a food source, given the food source's position relative to the sun? A class previously exposed to a specific example of this problem did well if given any version of the question (extra text + image, extra text, image, or neither extra text nor image). A naïve class, however, did best with extra text alone and worst with image alone. Unless the image clearly communicates the correct answer, it apparently serves as a distraction from the critical thought process.

Learning Goals: Our aim was to test for critical thinking when presented with different content, following lessons that either did not specifically address the subject of the test (Bio 105) or following a lesson that did address the subject of the test.

Lesson Plan: We included a one-page, multiple choice question in the final exam of each class that tested students' ability to answer a problem, given one of four versions, as described in the abstract.

Approach: We collected the single sheet from each student's final exam and separated the sheets into four categories by what type of information a student was given to solve the same problem and further categorized by which answer was selected for each content type.

Findings/Discussion: Students largely unfamiliar with the subject of the problem (waggle dancing in honey bees) in Bio 105 did no better than random when presented with version 4 (no image or additional text; 3/10), as expected, while most students exposed to a version of the problem in Bio 203 answered correctly (9/14), again as expected. Naïve students did moderately well when presented with image + extra text (5/11), better with just the extra text (7/9), and terribly (2/12) with image alone. These naïve students were likely distracted by the image's apparent solution without thinking critically about the text that came with all versions. Experienced students (Bio 203) did moderately well with image + extra text (8/15), but did better with just image or just extra text (12/15 for each). We look forward to presenting students with different example problems and to further test how visuals can either aid or distract from critical thinking and problem solving.

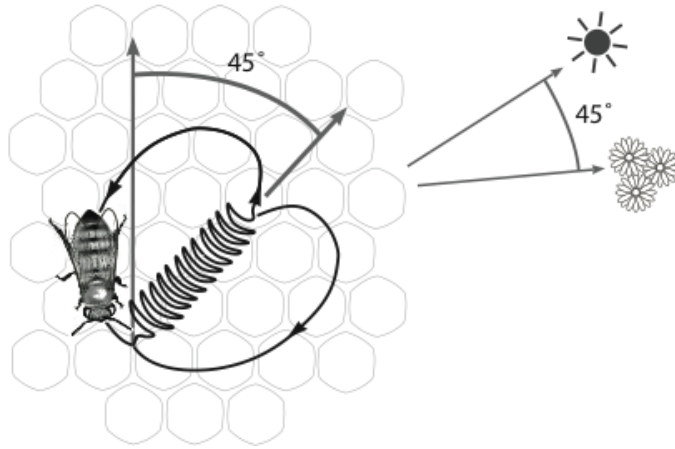
Lesson Materials: See attachments for different versions of the problem administered to Bio 203 students. Bio 105 students were given the same problem, but were also asked if they had heard of the "waggle dance."

61. Considering the information given below, answer the following question about honey bees.

If a honey bee found food 90 degrees to the left of the sun when leaving her nest, how would she communicate the location of this food to her nest mates?

She would:

- lead them to the food by directly guiding them from the nest.
- leave a chemical trail for nest mates to follow.
- dance at 90 degrees to the right of the vertical in the nest.
- dance at 90 degrees to the left of the vertical in the nest.
- dance at 45 degrees to the right of the vertical of the nest.



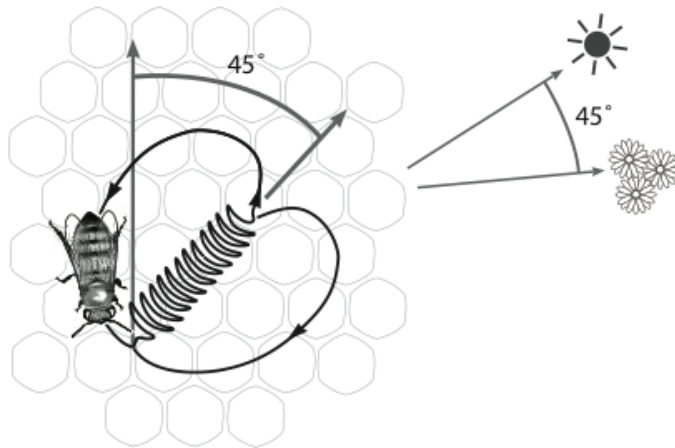
Honey bees (*Apis mellifera*) are herbivores that build combs of wax that hang vertically inside dark, hollow cavities of trees. To collect food, worker honey bees forage for nectar and pollen by flying from their nests, seeking flowers, then returning to the nest with food to share. They can advertise the location of a food site to their nest mates by wagging their abdomen back and forth as they walk forward at an angle from the vertical direction on the comb. This angle communicated on the comb advertises the direction from the nest to the food because that angle matches the deviation of the angle between the sun and the food when departing the nest.

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