

# Text versus images as tools when solving conceptual problems

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## OBJECTIVE

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, lacking extra text or 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 (Fig. 1)?

**Background:** Honey bees (*Apis mellifera*) can communicate direction and distance to a destination by performing a waggle dance. The angle of her dance relative to the vertical direction on the honeycomb matches the angle of the advertised destination relative to the position of the sun when leaving the nest.

## METHODS

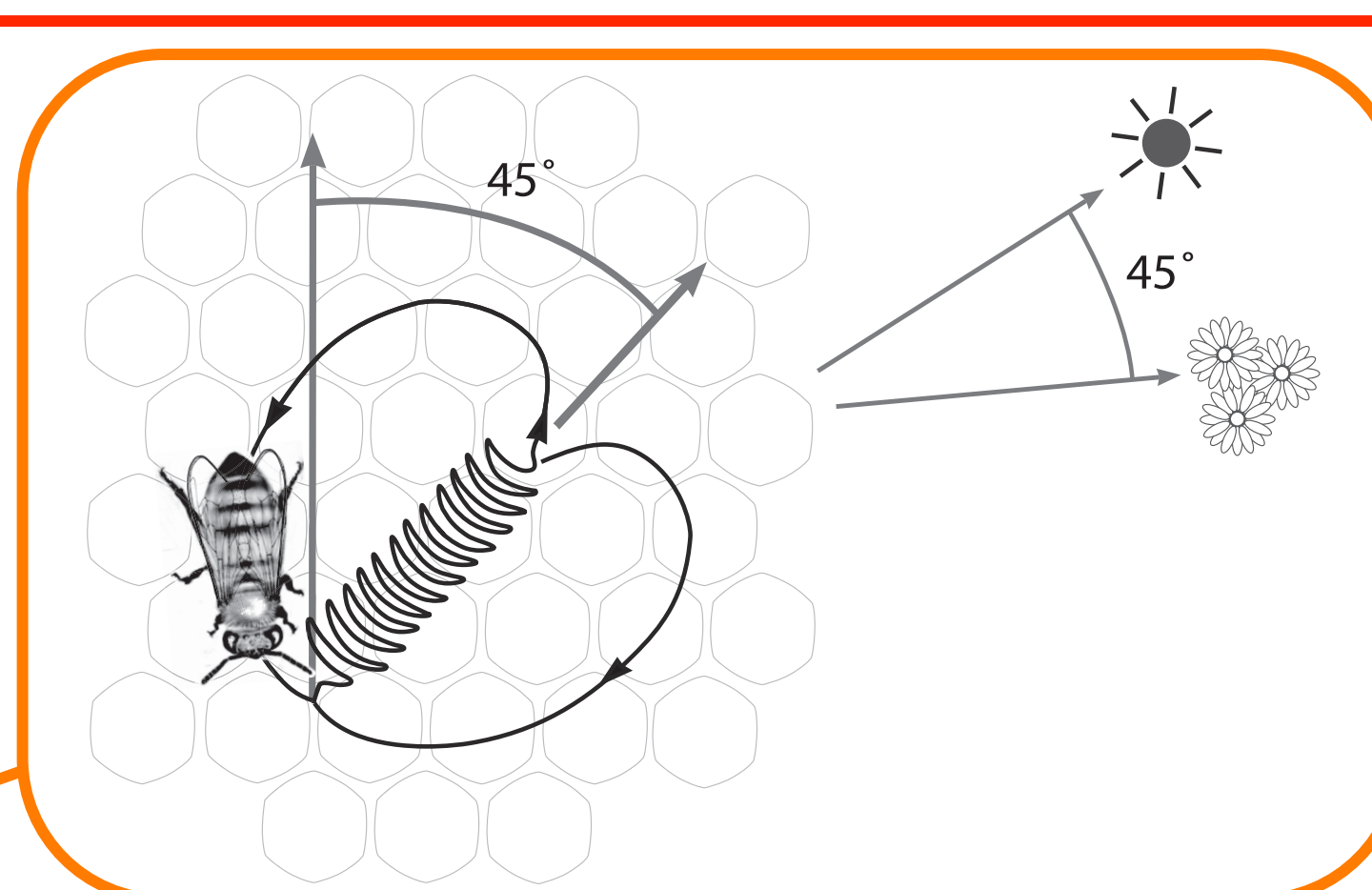
We included a one-page, multiple choice question in the final exam of one lecture section of General Biology and Organismal Biology to test students' ability to answer a problem, given one of four versions (Fig. 1): Question +

- (1) image + extra text,
- (2) image,
- (3) extra text, or
- (4) neither image nor extra text

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. 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. Bio 203 students were exposed to a version of the problem during one class.

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:

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

**Figure 1.** Four versions of a multiple choice question, each beginning with the actual question (text above image) and either followed by text + image, image, text, or neither text nor image. The correct answer is d.

## RESULTS

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), and did 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).



**Figure 2.** Number of students in General Bio (top) & Organismal Bio (bottom) who, given different versions of the problem (question plus: text + image, image, text, or neither text nor image), answered a-e. The correct answer is d, circled above.

## (tentative) CONCLUSION

A class previously exposed to a specific example of this problem did well if given any version of the question (Fig. 2, bottom: d). A naïve class, however, did best with extra text alone and worst with image alone (Fig. 2, top: d). Unless the image clearly communicates the correct answer, it apparently serves as a distraction from the critical thought process.

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.