


Research Article

Into the Buzzing World: Integrating Artwork with Fieldwork to Learn About Bees

Luyao Huang¹, Xue Fang¹, Daihu Yang^{1,*} , Zhanjun Wang¹, Min He², Hualun Chu³, Qing Zhang²

¹Department of Biological Sciences, Hefei Normal University, Hefei, China

²Hefei No. 45 Middle School, South Furong Campus, Hefei, China

³Guoyang No. 6 Middle School, Bozhou, China

Abstract

This article describes a pedagogical approach that integrated artistic expression with experiential fieldwork to enhance pupils' learning of bees. Initially, pupils were tasked with creating an artwork of a bee or bees based on their preconceived notions, allowing teachers to identify their prior ideas of bees. Afterward, an immersive field activity was conducted to provide pupils with an opportunity to close-up observe live honey and native bees in canola fields and their pollination processes. Through teacher-guided explorations, pupils systematically inspected the morphology of various bee species, relating their external structures to associated functions. The fieldwork allowed for detailed observations of bees' features, such as the proboscis, antennae, and legs, and their roles in nectar collection and pollen distribution. In addition, exposure to honey and native bees informed pupils of the differences in their stinging, nesting and sociality. Pupils' summative reflections post-fieldwork suggest that the immersive fieldwork enabled multi-sensory modes of learning barely available in a traditional classroom setting. By juxtaposing the new insights from field observations with the prior ideas of bees embodied in their initial artworks, pupils achieved gains in both their conceptual understandings and perceptual knowledge about bees. Pupils acknowledged deeper understandings of bee anatomy, pollination processes and the diversity within bee species. This approach to learning about bees epitomizes the value of empirical investigation for advancing pupils' scientific practices and understanding life science core ideas of how animals' external structures fulfill various functions and of how plants and pollinators are interdependent, as highlighted in *the Next Generation Science Standards*. The integration of artwork creation and experiential fieldwork exemplifies an effective pedagogical approach for enhancing pupils' engagement and learning of biological ideas.

Keywords

Bee, Artwork, Experiential, Field Activities, Enhanced Learning, Reflection

1. Introduction

Science education advocates for activities relating to empirical investigation as a beneficial approach to understand-

ing science practices [1]. This approach often entails scientists meticulously observing and documenting phenomena,

*Corresponding author: daihuy@hfnu.edu.cn (Daihu Yang)

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conducting disciplined fieldwork as well as constructing explanations via reasoning and creative thinking [1]. As such, empirical investigation is integral to the practice of science. Immersing pupils in these practices is pivotal for building their skills, cognitive and affective faculties. *The Framework for K-12 Science Education* identifies biological structures and interdependent relationships in ecosystems as core ideas of life sciences [1, 2]. Specifically, it expects students to understand that animals have external structures fulfilling various functions in growth, survival, behavior, and reproduction [1, 3] and that plants often depend on animals for pollination [1]. Most flowering plants rely on bees' pollination service for reproduction (Figure 1) [4]. Honey bees alone pollinate 80 percent of all flowering plants [5]. Bees' external structures have evolved to allow them to perform pollination while sipping nectar, thereby facilitating the reproduction of floral and arboreal species. There is no doubt that bees are very important to global food security. Three out of four crops that produce edible fruits or seeds for humankind in the world benefit entirely or partly from pollination service, primarily provided by bees [6, 7]. In a bee-less world, our gardens would be bleak and food barely available. For instance, honeybee extinction would cause our diets to drastically change. Many fruits and vegetables, including almonds, apples, avocados, and berries, rely heavily on bees' pollination service. Without bees, these foods would become scarce [8]. Despite the immense value of bees in sustaining plants and food supply, many pupils exhibit gaps in their knowledge of bees, suggesting a need for enhanced bee education.



Figure 1. An orchid bee (Source: *The Bee: A Natural History*).

This article elucidates how a school teacher leveraged in-class artwork creation and out-class investigative fieldwork centering on bees to promote pupils' learning of core life science ideas pertaining to external structures, associated

functions, and pollination. The paired activities of artwork creation and investigative fieldwork align with the dimensions of *the Next Generation Science Standards* [9]. The three-dimensional NGSS takes an integrated approach that combines disciplinary core knowledge, scientific and engineering practices, as well as crosscutting concepts [10]. Specifically, the artwork creation activity interwove scientific practices by providing the pupils an open-ended avenue to construct visual representations conveying their preconceived notions about bees. The fieldwork immersed the pupils in canola fields to observe bees firsthand and enabled them to hone skills in observation, documentation, and questioning. The crosscutting concept of structure and function in life sciences manifested itself through directly examining bees' external anatomy and discerning how body parts like the proboscis and legs enable essential functions of gathering nectar and distributing pollen. The pupils developed an appreciation for the way in which a living thing is shaped to determine many of its properties and functions [1]. Several life science core ideas came into play as well. The fieldwork activity connected to the core idea that animals have both internal and external structures that allow for growth, survival, behavior, and reproduction [1, 11]. The pupils learned how bees' external structures like specialized proboscis and hairy legs allow them to suck nectar and collect pollen to sustain their own survival and the growth of their offspring. Also, the fieldwork tied to the core idea of interdependent relationships in ecosystems [1], highlighting bees' symbiotic relationship with flowering plants, whereby these plants depend on bees for propagation through pollination.

2. Identifying Pupils' Prior Ideas Through Their Artworks

The Framework for K-12 Science Education asserts that students should be able to construct drawings or diagrams as representations of events or systems—for example, drawing an insect with labeled features [1]. Thus, visual representations are an integral part of the practice of science, enabling students to convey their scientific ideas [9, 12, 13]. In this vein, a teacher in a local school invited her pupils to create an artwork of a bee or bees by drawing in her class teaching. The teacher preceded the drawing activity with an introductory discourse on the importance of bees to humanity. Then the teacher prompted the pupils to reflect on what they knew about bees by posing the questions: How familiar are you with bees? Could you illustrate your ideas of a bee or bees through a drawing? Each of the thirty-three pupils was given a paper to artistically present one or more bees. This artwork creation aimed to evaluate the pupils' preexisting notions of a bee or bees through their artistic expressions. Following the drawing activity, the teacher collected and analyzed the pupils' drawings. She observed that the pupils harbored varying levels of understandings about the morphological features of

bees.

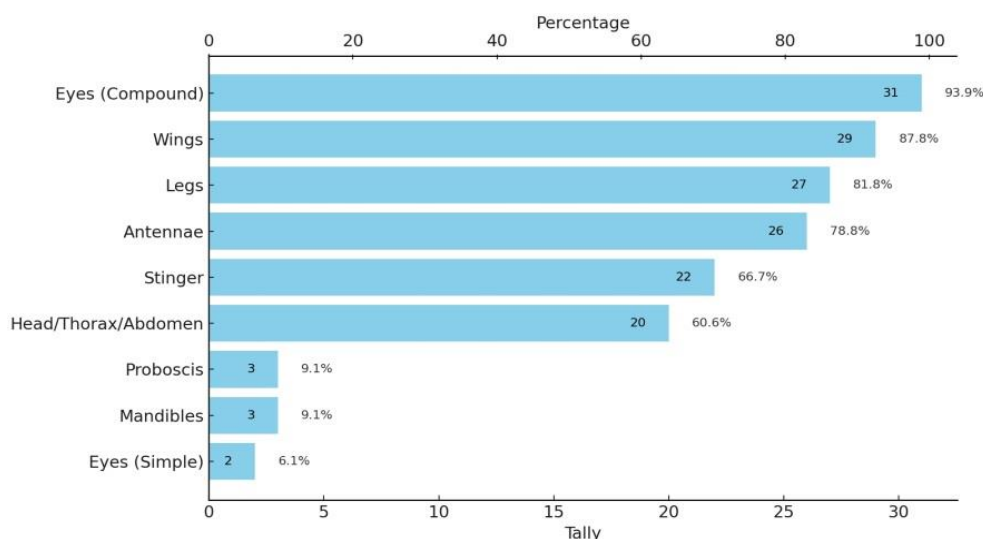


Figure 2. Tally and percentages of represented bee features.

As shown in [Figure 2](#), high incidence features relate to the head, thorax and abdomen (60.6%), compound eyes (93.9%), wings (87.8%), antennae (78.8%) and stinger (66.7%). Less prevalent are the proboscis (9.1%), simple eyes (6.1%), and mandibles (9.1%). Examining their drawings, the teacher also noticed that many pupils presented stylized drawings of a bee or bees, with some drawn bees' features being missing ([Figure 3](#)), improperly jointed and/or inappropriately quantified.



Figure 3. A pupil's stylized drawing of a bee.

3. Experiential Field Inquiry into Live Bees

In March every year, the suburban area near the school bursts into a vibrant sea of canola flowers. An expanse of canola flowers carpets the earth with yellow hue, permeating the air with fragrance. During the time, a swarm of bees, lured by the flowers' scent and nectar, create a buzzing

heaven over the canola flower fields. Capitalizing on this seasonal opportunity when bees are easily spotted and caught amidst the blooming flora, the teacher intended to usher her pupils into the fascinating world of live bees.

Prior to the outing, the pupils were given magnifying glasses and forceps to allow them to handle bees and closely observe flower pollen and bee anatomy. Along the trail leading to the canola flower fields, the teacher and pupils paused at a patch teeming with bees hovering and gathering nectar among the blossoms. The teacher requested them to sit quietly for a few moments, attuning their sensory to the environmental rhythms in the field. Then the pupils were encouraged to engage their senses—touch, sight, hearing, and smell—to observe the bees closely and make detailed notes of the bees in their notebooks.

Their first mini-session of the fieldwork activity related to identifying the types of the bees flying amidst the canola flowers. Group discussions ensued regarding the different shapes, sizes, and colors of the bees spotted. During the discussions, the teacher noticed that many often mistook similar flower flies for bees. To clarify, the teacher used a net to catch both a bee and a flower fly for comparing their physical appearances. While remarkably alike, a careful examination revealed key distinctions. The teacher highlighted the distinctions—the flower fly's stubbier antennae, single pair of wings versus the bee's two pairs, larger eyes covering a significant portion of its head, hairless legs unfit for collecting pollen and the lack of bee-like stinger and mandibles.

During their observations, some bees were spotted bearing yellowish pollen clumps on their hind legs. Seizing this was an opportunity to explore pollination, the teacher asked: how these pollen balls enable the flower reproduction? After a discussion, the pupils started to dissect a flower under the

teacher's guidance, examining the stigma and stamens. Afterwards, they carefully and silently watched honeybees sipping the nectar inside the flowers, noting how the pollen from the stamens stuck to the insects' hairy bodies. When these pollen-laden bees visited another bloom, the stuck pollen could be transferred from their body to the stigma, fertilizing the flowering plants. This brought to life the vital role bees play as pollinators.

The activity then progressed to exploring bees' morphology up close. Using forceps, a pupil held a bee while his peers viewed it through magnifying glasses. Carefully, they examined how the head, thorax and abdomen connected serially, with the thorax situated between the other two segments. Viewed head-on, the bee's triangular head features two compound eyes for sensing shapes and colors, plus simple eyes (ocelli) helping orient the insect. Sensory antennae can detect signals like chemicals and vibrations. At the mouth, mandibles serve as teeth to bite intruders or chew materials in nest building. The teacher invited the pupils to closely observe a honeybee unfurling its long, straw-like tongue into a flower, then to relate this proboscis shape back to the canola blossom structure. The pupils realized that the elongated proboscis allows the bee to efficiently collect the nectar at the base of the canola flowers.

After examining the head, the pupils started to explore the bee's thorax, which powers wings for beating and legs for locomotion via strong muscles within. In observing the wings, they noted two large forewings and two small hindwings anchored to the thorax. The wings of various bees caught by the pupils exhibit a wide spectrum of sizes and colors, ranging from small and transparent to large, dark and iridescent. The teacher explained these bees' wings enable flight to carry pollen and nectar and fan fresh air to cool off the heat in their nests. The pupils cautiously touched a caught bee to relate the movement of its wings to the buzzing sound. The bee stopped buzzing when its wings halted flopping and its body vibrating. The pupils speculated that the bee's buzzing sound was correlated with the rapid beats of its wings. Upon examining the legs, the pupils located three pairs appended to the thorax.

Transitioning their focus to the tapering abdomen, the teacher elucidated that it serves as the hub for nectar storage, respiration, digestion, and reproduction and added that some female bee species' abdomen harbors a stinger for defense. Building on this, the teacher sought to further the pupils' understandings of the differences between male and female bees. She captured a native carpenter bee and playfully challenged the pupils to hold it. Most pupils would not venture to do so for fear of getting stung. "Don't *BEE* afraid," the teacher reassured, holding the bee between her bare fingers right in front of them. Sighting her fearless show, the pupils erupted in shrieks, bewildered by her fearlessness. "Why aren't you scared of getting stung?" they inquired. With a smile, the teacher explained that the bee she just picked up is male. Male bees are stingless. She then launched into an im-

promptu mini-lesson on identifying male and female bees. "It's quite easy," she explained, "Native male bees have a lighter, whiter face and much larger eyes than their female counterparts."

Next, the teacher intended to address a common misunderstanding by a prompt: "Do bees die after stinging?" Most pupils nodded, arguing that their barbed stingers wouldn't retract without causing an abdominal rupture. To correct the misunderstanding, the teacher again used a female native carpenter bee as an example to show the pupils how its stinger can sting a soft rubber multiple times without any observable abdominal injury thanks to the stinger's smoothness. "So, as you see," the teacher emphatically clarified, "not all bees fatally rupture themselves after stinging!"

The field activity culminated in a spotlight on native bees, an under-represented topic in biology curricula. The teacher posed a thought-provoking question to the pupils: where do bees go after sunset? The pupils responded that bees would retreat to their shared hives. But the teacher had a surprise in store. Guiding the pupils to an abandoned adobe hut with a bamboo-pole roof, the teacher pointed to the hut's clay wall riddled with holes which little native bees were seen buzzing in and out of. "These," the teacher explained, "are the bees' homes, drilled with their own mandibles." "Inside these tubular nests," as the teacher called them, "the bees would lay eggs on pollen and nectar deposited in the partitions of the tubular nests." The teacher directed the pupils' attention to the bamboo canes that made up the base layer of the roof of the hut. "Up there, you can see some holes in the internodes of the bamboo canes. Some native bees, for example black carpenter bees, burrow into hollow cavities in bamboo canes to build their tubular nests in which they unload pollen from their legs and spit up nectar through their proboscis to create a nutrient-rich pollen-nectar mixture that hosts their laid eggs." This explanation sparked a flurry of discussions about the native and honey bees among the pupils. They were fascinated to learn that, unlike the social honeybees with their queen, these solitary bees are single mothers, raising their offspring without the help of a colony. As a matter of fact, most bee species in the world live a solitary life, tending to their own individual nests.

At the end of the field activity, the pupils were tasked with a reflective writing assignment. To guide their summative reflections, the teacher provided a prompt: "Revisit your initial drawings to consider if your ideas of bees remain the same or have been transcended with your new understandings from the field activity?" This invitation to retrospection served as a springboard for them to engage in critical reflections, reviewing their prior knowledge in relation to their new insights from the field activity.

4. Assessing Pupils' Reflections

Several days after the fieldwork, the pupils submitted their reflective writings, brimming with enlightenment from their

experiences with live bees. Later, the reflective writings underwent content analysis [14, 15] and emergent coding [16] to extract the themes illuminating the pupils' prominent ideas about bees from their summative narratives in the writings. Analysis suggests the pupils appreciated the field-based inquiry for advancing their bee literacy in ways hardly available in a traditional classroom, as a student expressed her enlightenment on bees:

This fieldwork has transformed my knowledge about bees! I previously thought all bee species lived in colonies like honeybees. Seeing solitary native bees nesting in hollow bamboos and boreholes in wood opened my eyes to the diversity within the bee population. Using a magnifier, I got a close-up view and spotted so many intricate details I never knew were there - varied wing shapes, colors, wingbeats producing humming sounds and sizes, exquisitely suited to flowers. Now I understand more profoundly bees' key roles in nature and the importance of protecting them.

The prominent themes mostly highlight their newfound knowledge about the segments of a bee's body as well as the differences between honey and native bees, as observed during the fieldwork. For instance, many pupils expressed their surprise at their discoveries about bees' head, noting specifics such as the precise location of the eyes and antennae (e.g., *now I know the exact positions of the eyes and antennae on bees' head*), the existence of simple eyes (e.g., *I have never expected bees have simple eyes*) and the functionality of bees' proboscis (e.g., *it is marvelous that bees' tongue can be elongated*). Similar revelations were noted regarding the thorax, with some pupils realizing the connections between the thorax, wings, and legs (e.g., *"I now know bees' wings and legs are anchored to the thorax"*; *"The droning and buzzing sound was generated by the rapid movement of wings, which is powered by the thorax."* *"The thorax is amazing to drive the wings to beat so rapidly"*). Their observations about the abdomen also yielded new understandings (e.g., *"I had thought that bees breathed through the nose like us. Now I know bees breathe through the abdomen after I saw the abdomen was contracting and relaxing."*; *"I did not expect native bees can sting multiple times without abdominal damage."*)

The fieldwork activity also broadened and corrected their prior perceptions about bees, as some pupils saliently articulated in their reflective writings:

I had thought all bees were social and lived together in colonies before the field investigation. Now I know that social bees like honeybees only account for a small portion of all bee species worldwide.

Many solitary bees' nests are tubular, quite unlike my early notion of a ball-shaped nest hung in a tree as represented in my drawing.

I realize my drawing of a bee with two wings and four legs is wrong after observing live bees' anatomical fea-

tures more closely - bees properly have two pairs of wings while flies only have one.

5. Conclusion

The pre-fieldwork drawing activity allowed the teacher to identify the pupils' prior knowledge of bees while giving them an opportunity to revisit and reflect on their prior perceptions exhibited in their drawings in relation to their new realizations of bees from the fieldwork activity. Against their multi-modal field observations of live bees, the pupils were able to identify specific points of misalignments in their artistic representations. The authentic field context provided a fertile playground to supplement, rectify and correct their prior conceptions of bees embodied in their artworks with reality-tested insights. In the canola flower fields the pupils employed full faculties—not just cognitive, but also visual, auditory, olfactory and tactile inputs. After the fieldwork activity, the pupils acquired corrected conceptual understandings about bees, along with perceptual insights into bees' color, sound, odor, and vibrations—an experiential depth rarely achievable through traditional multimedia-based learning within the classroom setting. The artwork creation and fieldwork activities enabled the pupils to engage in authentic scientific practices and embodies life science core ideas highlighted in the *Next Generation Science Standards*.

Abbreviations

NGSS The Next Generation Science Standards

Author Contributions

Luyao Huang: Funding acquisition, Data curation, Formal Analysis

Xue Fang: Project administration

Daihu Yang: Conceptualization, Funding acquisition, Formal Analysis, Writing – original draft

Zhanjun Wang: Final Review, Correction

Min He: Investigation, Methodology, Project administration

Hualun Chu: Project administration

Qing Zhang: Investigation, Methodology, Project administration

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Conflicts of Interest

The authors declare no conflicts of interest.

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