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Nuts about Inquiry: Peanut Variation and Natural Selection

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NUTS ABOUT INQUIRY

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USING PEANUT VARIATION TO TEACH NATURAL SELECTION

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ABSTRACT: Despite the numerous advantages of using inquiry, many teachers do not use this method because of issues such as time constraints and increased workload. In addition, content such as evolution is particularly problematic to teach because of the perceived lack of hands-on activities and societal pressures. This inquiry activity is designed to help students understand an important component of evolution by natural selection. Through this activity students better understand natural variation within populations using peanuts. Students are encouraged to make links between population data, population diversity and evolution by using collected data to construct and interpret graphs. *This article promotes National Science Education Content Standards A, C, and G, Iowa Teaching Standards 1,2,3,4, and 5.*

Evolution is a challenging topic. Many science teachers struggle to teach it, and many students struggle to understand it. This struggle is, in part, due to the political controversy associated with teaching the topic. The problem is exacerbated by a lack of hands-on activities that promote deep student learning. Understanding evolution is particularly challenging because of the numerous smaller concepts, such as natural selection, variation within populations, selective pressures, differential survival, genetics, and reproduction that interact to support the main idea of evolution. The challenge for teachers is to select and present materials and activities that scaffold students from these smaller concepts to how these components fit together to form a cohesive picture of evolution.

Hands-on does not guarantee minds-on. Teachers must use caution when choosing activities which aim to promote student understanding. Many "hands-on" activities fail to mentally engage students; rather, these activities tell students what and how to think. The danger of these activities, termed "cookbook" activities, is that they often hinder students' development of a deep and robust understanding of fundamental science ideas. Unfortunately, the manipulation of objects masks the lack of mental effort.

In contrast, inquiry based activities promote student understanding by requiring mental activation and engagement. When used effectively, inquiry activities promote many of the goals we have for our students including deep and robust understanding, teamwork, effective communication, problem solving and critical thinking. Yet, planning inquiry activities can be overwhelming. Instead of starting from scratch, we have modified a “cookbook” lab so that it requires students to be more meaningfully and mentally engaged.

The Original Activity

In the original activity, students are given a paper lab and are instructed to begin the task with little instruction and no rationale for doing the activity. Students crack open and measure the length of thirty peanuts and then record their results on the provided graph. While this activity seeks to demonstrate the important concept of natural variation within populations, students do not develop a deep and robust understanding of this concept because little cognitive effort is required to complete the task. Students are told how to measure, how to plot their data, and there is no explicit connection made to previous activities or material covered in class. However, all was not lost! We realized how we could modify this activity to help our students make meaningful connections to big ideas and promote critical and creative thinking in our students.

Investigating Peanuts

Before beginning this activity, poll your students to determine if there are any peanut allergies. In addition to talking to students, you might also talk with the school nurse or other health official to ensure the accuracy of student's statements. If there is a peanut allergy, an alternative item will have to be used; suggestions include beans or any type of naturally variable produce. The key point here is that the trait being measured, such as length or width, is variable within the population. If using an object besides peanuts, the teacher should perform the lab before students to ensure variability within the population.

One of the most important modifications we made was connecting the lab to previous classroom discussions and activities. By asking a few review questions regarding the process of natural selection, we help students develop a context for the investigation. In previous class sessions, students had been introduced to the idea of natural selection and this investigation adds to the idea by incorporating natural variation and differing selective pressures into the process of evolution. To help students make connections to previous learning, we ask them to review with their partners what they know about natural selection. While they discuss, we walk around the room and pose follow-up questions and listen to see what conceptual hurdles students have yet to leap. Some questions we ask include

- “What might cause a mutation to be selected for by nature?”
- “How might the selection process result in changes to the population?”

Once students have reviewed previous content, we introduce the task for the day by saying, “Since some variations are selected for more frequently then others, we are going to spend some time investigating variations in organisms.” We challenge students by asking

- “What characteristics of a peanut could we use to measure variation within a population?”

At this point students usually say mass or length; this can lead to a fruitful discussion regarding what characteristic would be best for measuring. During this discussion we ask follow-up questions such as

- “What are the pros and cons of using mass to measure variation within a population?"
- "What are the pros and cons of using length to measure variation within a population?"
- "What additional considerations, such as limitations of the classroom, do we need to consider when choosing what characteristic to measure?”

By helping students determine what characteristic to measure, they develop a better sense of ownership and engagement in the activity because their ideas help steer the direction of their investigation.

In order for our discussions to be fruitful, we are careful not to respond to student ideas too quickly. Rather, we wait for other students to comment. We want students to evaluate each other's ideas and make decisions, not wait for us to simply tell them what to do. In addition to waiting, we move and look around the room expecting students to comment. We do not evaluate or critique student ideas at this point, but instead ask for clarification or seek other ideas. We use this approach in order to maintain open dialogue in which students feel safe sharing their ideas. If students do not share their ideas, we cannot know what they are thinking.

Before distributing the items to be measured, we ask students to come up with a procedure for investigating the variation in the peanuts. We guide the discussion by asking questions such as

- “What unit should we use to measure the peanuts?”
- “How are you going to record your results?"
- "What are the pros and cons of using this particular method to record results?”

So that they think more deeply about their decisions, we expect students to defend their approach. Notice, we are not simply giving the students directions, but we are providing carefully thought out guidance so that they are successful. While this approach may take more time, the demand placed on student thinking is worth it.

Sometimes we have students collect their length data before discussing how to analyze the data; sometimes we discuss analyzing the data first. In either case, we ask students how they might "visualize" their data. Students usually quickly say we should graph the data, but then we ask what kind of graph we should make. Students often struggle with this question largely because they are not accustomed to having to make such decisions.

Many students will want to initially create a line (x,y scatter plot) relating peanut number (determined randomly as a by-product of data recording) and peanut length. At this point, we intervened by asking students

- "What data are typically plotted using line graphs?"
- "What might a line graph convey about the data?"
- "What sort of information are we trying to convey regarding our data collection?"

By asking these questions, students can be guided to realize that these data are not appropriate for a line graph. We then asked another question

- "What other graphs have you used to help represent data?"

Students will often say bar graph and pie charts. Using a questioning pattern similar to that outlined above, we guide students to the idea that a bar graph would most appropriately represent their data because we are interested in the number of peanuts in a given length range. To help students understand how graphs abstractly represent data, we created a series of tubes designed to hold the peanuts grouped by length (Figure 1). Students then place their peanuts in the appropriate tube. Once all the peanuts are placed into the tubes, students discuss what they observe about the tubes. Students often first notice that there are more of the middle-sized peanuts and fewer peanuts of the largest and smallest sizes (Figure 2). Students, provided with the concrete experience of creating this size distribution, more easily understand an abstract representation of the tubes using graph paper.

TUBE MATERIAL LIST

Base: 2x4 boards
Vertical supports: 5/8-In dowels
Tubing: 1-3/4 inch diameter clear tubing
Zip ties

CONSTRUCTION TIP

For a more economical and quick way to create the "peanut graph" we have found small diameter graduated cylinders to be useful.

Bridging Data and Theory

The next important step in this investigation is to connect students' observations to the larger processes of evolution. To help students understand how this natural size variation is a critical component in the process of evolution, we pose a scenario to students.

"Imagine a predator enters the peanut field and because of its small beak is able to eat only peanuts smaller than fifteen millimeters. How do you predict this would change the size distribution of the peanuts?"

Some students struggle with this question and we have to ask other questions to help students understand the scenario. We use questions such as

- "Think about the fact that genes are passed from parents to offspring. What would happen if only peanuts smaller then fifteen millimeters are eaten?"

Students will typically say that there will be fewer small peanuts in the next generation.

At this point, we empty any tubes with small peanuts to help students concretely track their thinking. We then ask

- "How might having fewer small peanuts in the field impact the number of larger peanuts in the next generation?"

We help students understand that there will be a corresponding increase in the number of large peanuts. Then, students add more peanuts to the appropriate size tube to represent the increase in number of larger peanuts in the next generation (Figure 3). Once again, students are asked to observe the tubes and, more importantly, to note similarities and differences between the size distributions.

By being asked to think through the scenario and being supported in their thinking by physically manipulating the number of peanuts in the tube, students come to realize that the size distribution will shift to larger size peanuts.

Once students have developed their understanding of the concept, we then introduce the term directional selection.

FIGURE 1
One tube unit of the concrete representation of a bar graph.

Photo by Lindsay Kasuga

FIGURE 2

Students add peanuts to the tubes and notice a distribution similar to this photo.

FIGURE 3

Students add peanuts to subsequent generations and observe how the populations pattern changes.

Photos by Lindsay Kasuga

Using a procedure similar to that outlined above, we pose two additional scenarios:

"Imagine a predator enters the peanut field and because of the shape of its beak is able to eat only peanuts between the sizes of fifteen and twenty-five millimeters. How do you predict this would change the size distribution of the peanuts?" and

"Imagine a predator enters the peanut field and because of the shape of its beak is able to eat only peanuts smaller than fifteen millimeters or larger than twenty-five millimeters. How do you predict this would change the size distribution of the peanuts?"

QUICK TIP

Depending on your purpose, consider dying or marking in some way the "next generation" peanuts so that students can more easily distinguish between the P and F1 generations.

Students, after given time to think-pair-share and manipulate the number of peanuts in the tubes, can usually accurately predict how these predators, described above, would change the shape of the distribution curve; we label these situations as disruptive selection and stabilizing selection, respectively.

Conclusion

Our guiding questions throughout this activity highlight the critical role of the teacher in inquiry activities. In traditional cookbook activities the students can often perform the task without the teacher even being present! In contrast, inquiry activities demand much more of teachers. Instead of simply telling students answers we encourage them to reason through and use their previous learning to make sense of information. Oftentimes the most important thing we can do to encourage students to think is to reduce the amount of our own talking. Although teaching through inquiry is demanding, the rewards for both the teacher and students are well worth the effort.

References

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