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Graph It Out! Create Graphing Manipulatives to Explore Evolutionary Selection: A Lesson for High School Biology Students

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Students often struggle with the relationship between mathematical graphs and the data they represent. To truly understand types of evolutionary selection, students need to be proficient with several different skills in math, science, and literacy contexts. With math, students must be able to identify variables, design appropriate graphs based on those variables, and convert data to graphical format. With science, students must be able to relate identified variables to scientific classifications and interpret those classifications based on evaluation of the scenarios presented. With literacy, students must be able to comprehend, dissect, and interpret a given passage. This presentation provides a multifaceted approach to teaching about types of evolutionary selection by making and using graph modeling manipulatives. Though the examples provided in this presentation are primarily focused for biology teachers, anyone who teaches students to interpret graph data could find the graphing manipulatives to be a useful tool as well.

Keywords
Graphing Skills, Graphical Interpretation, Modeling, Evolutionary Selection, Secondary Biology

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Introduction

Students often struggle with the relationship between mathematical graphs and the data they represent (Gültepe, 2017; Roth & Temple, 2014; Tairab & Khalaf Al-Naqbi, 2004). This struggle can carry over into other areas of study that call for an understanding of the correlation between information and representation.

To truly understand types of evolutionary selection, students need to be proficient with several different skills in math, science, and literacy contexts. With math, students must be able to identify variables, design appropriate graphs based on those variables, and convert data to graphical format. With science, students must be able to relate identified variables to scientific classifications and interpret those classifications based on evaluation of the scenarios presented. And with literacy, students must be able to comprehend, dissect, and interpret a given passage.

What makes this following lesson so powerful is that it provides students with a multifaceted approach to learning about types of evolutionary selection by using small groups and graphing manipulatives, in addition to developing each of the skills mentioned previously. This activity is designed to be done after the initial introduction of the concepts and before individual practice.

Making the Graphing Manipulatives

Necessary materials (for a class size of 30):

- 1 large foam board (tri-fold presentation size, approximately 36”x48”)
- 10 green felt craft squares (8.5”x11” size)
- 1 roll of bright yellow* yarn (something replaceable)
- 1 roll of purple* paracord (or strong, waxed cord)
- 1 tube of all-purpose glue
- 1 box cutter or some other razor knife
- 1 black permanent marker
- 1 hot glue gun and glue

**The colors listed here are only suggestions because of the contrast. You can use any contrasting colors you prefer.*

Assembling the manipulatives

1. Use razor knife to cut foam board into 10 9”x12” size sections.
2. Place 1 felt square on each foam board section and adjust accordingly to make the most efficient cuts; do not allow felt to overlap the notches in foam board too much; this will cause folding in the felt when the yarn is added.
3. Trace around the edges of the felt squares and then place them off to the side.
4. Use the all-purpose glue to affix the felt squares to the newly cut foam board backs. (Reminder: be sure to leave a 1/2” margin of foam board around the edge of the felt sheet)
5. Use the box cutter or razor knife to cut notches into the foam board to secure the yarn. Do not cut through the felt. See Figure 1.

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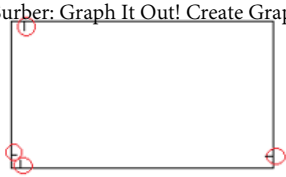
Figure 1.

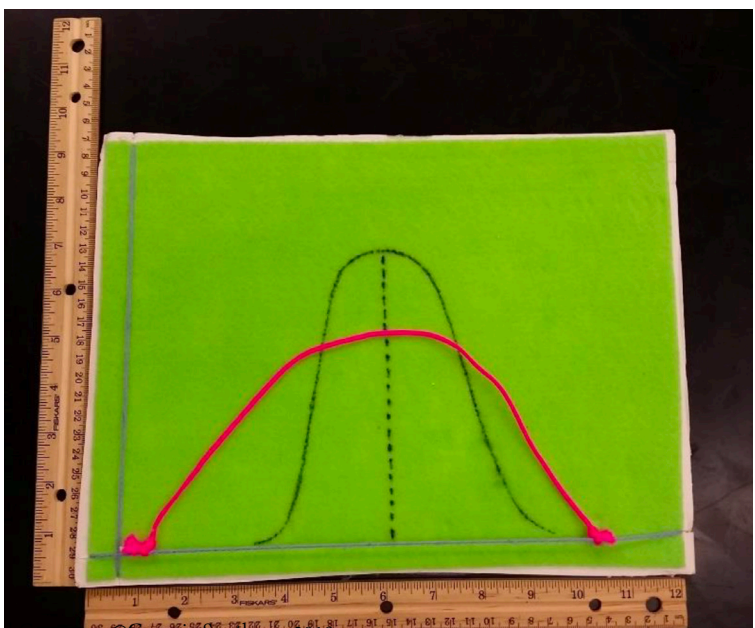


6. Use the yellow yarn to define the x-axis and y-axis of the graph. Tie the ends on the back of the foam board and either tape or hot glue the knots to the foam board.
7. At this point, the manipulative should look similar to Figure 2.

Figure 2.

8. Sketch a bell curve on the felt in the center.
9. Cut a length of paracord approximately 10 to 12 inches long; you will need to be able to tie loops in the ends and still have enough length to create a disruptive selection curve.
10. Tie the ends of the paracord into loops around the yarn creating the x-axis. Be sure to leave some space in the loops so the cord can still slide over the yarn.
11. Hot glue the knots to prevent unraveling. Be careful not to hot glue the cord to the yarn.
12. Repeat with the other 9 units. This should result in 10 manipulatives that look similar to the board pictured in Figure 3.

Figure 3.

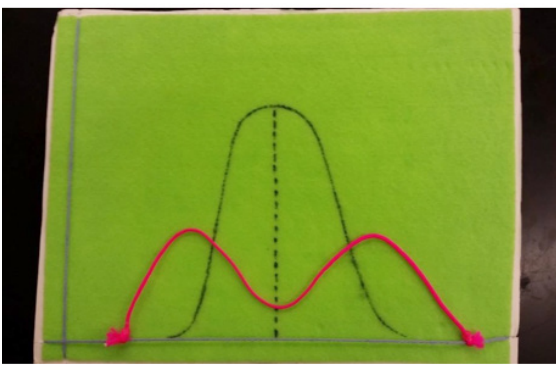


Students of similar skill levels should be assigned to groups of three. This encourages participation by all group members during the lesson. Often when students are placed in a group with a single strong student, the others may tend to not be as open with their ideas. This is especially true with this lesson where students are presented with new information and a novel way of expressing that information.

To begin, the teacher should briefly review the types of selection (stabilizing, selective, and disruptive) with the students and then provide a few possible scenarios. A good starting scenario might be to talk about populations of mice, white, gray, and black living near a volcano. Before a recent eruption, gray mice were selected against. After the eruption, their habitat is now the light gray color of the ash. Both the white and darker mice are easily seen against the light gray volcanic ash, making them more vulnerable to predators. Due to the selection against the white and black mice, the light gray mice have an increase in population because their fur color acts as a camouflage in the ash.

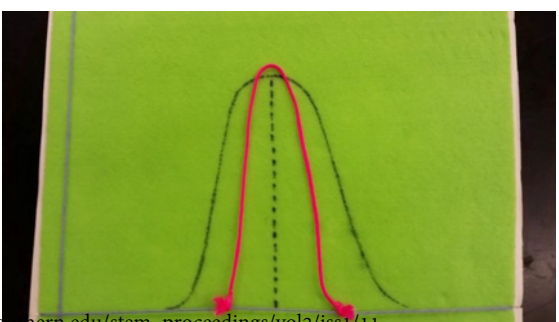
Students should be encouraged to discuss relevant variables within their groups and what population(s) they believe to be present in each scenario to begin with and manipulate their graphs to reflect that initial scenario. In this example, students should start with two different populations at either end of their graph with a dip between the two extremes. (See Figure 4.)

Figure 4.



They would then likely want to demonstrate stabilizing selection on their graphs. To do this, they would pull up on the string at the center of the graph to indicate an increasing population with the more moderate trait (i.e. light gray mice). As they pull up on the string, the two beginning population extremes disappear, more clearly illustrating the shift in the population toward more moderate traits over time. (See Figure 5.)

Figure 5.



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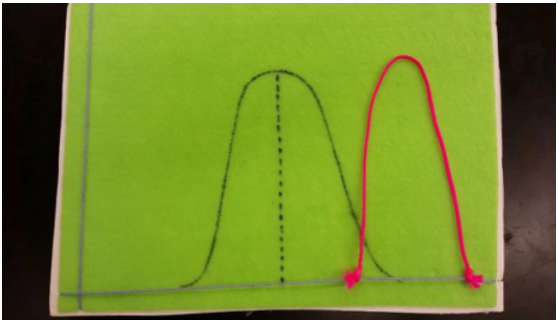
This technique can be used to demonstrate all types of selection. For an example with directional selection, students would pull up on one side of the string on the graph which then causes the height of the original peak to decrease or shift as the new peak is formed (pulled up). (See Figure 6.)

Figure 6.



Throughout this activity, the scenarios given are projected onto the screen so that students can re-read the example scenarios as needed. This is helpful because the examples gradually get more and more challenging. At the beginning of this activity, the teacher should read the passage to the class and guide the entire class in identifying the variables together. As the students work through the examples, the teacher should provide progressively less input as to what variables are important for consideration. For the final, more difficult examples, no help is provided other than reading the scenario aloud to the class. To start with, students were generally given two minutes to figure out their response to the scenario and manipulate their graphs accordingly. The time can easily be adjusted based on student need, class length, or speed of advancement through the activity.

Once the timer sounds, each group representative holds up their graph for the class. If there are varying answers from different groups, the teacher should not immediately identify which graph is correct or incorrect. What has typically worked well for this activity is to have a delegate from each group explain the group's rationale. Once the thought processes for all varying answers have been discussed, the class can usually come up with a consensus on what they believe the correct answer to be. Finally, the teacher can verify or provide the correct graph and lead a discussion as to why that particular representation is the most accurate.

Conclusion

This activity has met with considerable success in the classroom as determined with formative and summative assessments. Students enjoy the hands-on aspect of the graphing manipulatives, but also understand the processes of selection more thoroughly than without. Additionally, the majority of students typically are better able to apply their understanding to pictorial graphical representations after engaging in this activity.

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