Ants and Graphs

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Creighton Middle School – 8th grade
Interdisciplinary
Time length: 50 minutes

OVERVIEW

This lesson is intended to be a demonstrative activity that integrates two different types of disparate graduate research: graph theory and the behavior of ant colonies. Students have already been exposed to graph theory as well as to the ways in which ant colonies behave in different contexts and in the presence of different cues. This activity will show how the social interactions of both humans (the students themselves) and small groups of ants can be measured and charted using modeling techniques borrowed from graph theory.

PURPOSE

Students will be exposed to actual graduate research and how that research can be integrated and applied. Using graph theory models, students will help to create a visual representation of their own social interactions and be able to compare these to the type of interactions that result in groups of ants. Students will be able to compare the interaction patterns of two different species: humans and ants. Humans tend to have interactions that are consistently reinforced between specific individuals and should produce graphs that represent this. Ants have no such defined interaction patterns and should produce more diffuse patterns of interaction that are less weighted toward specific individuals.

OBJECTIVES & STANDARDS MET

Objectives:
   a) to reinforce students' observational technique
   b) to demonstrate variances in behavior between two very different species
   c) to show how biological observations can be modeled mathematically and visually
   d) to reinforce material presented throughout the year based on the research of GK12 residents

Science Standards:
1.1 Ask questions and state hypotheses that lead to investigation and design
1.2 Use appropriate tools, technologies, and metric measurements to gather and organize data and report results
1.3 Interpret and evaluate data to formulate a logical conclusion
1.6 Communicate results of their investigations in appropriate ways
3.11 Changes in environmental conditions can affect the survival of individual organisms, populations, and entire species
5.4 Models can be used to predict change

Mathematics Standards:
1.2 Formulate, represent, and use algorithms with rational numbers flexibly, accurately, and efficiently
3.1 Visual displays and summary statistics with one-variable data condense the information in data sets into usable knowledge
4.2 Direct and indirect measurements can be used to describe and make comparisons

BACKGROUND INFORMATION & REFERENCES

Background:

Students must have prior knowledge about the behavior of ant colonies. They also must have prior knowledge about Graph Theory, including the definition of a vertex and edge.

References:
Mike Greene and Mike Ferrara

VOCABULARY, MATERIALS, PREPARATION, SAFETY

Vocabulary:

Ant
Chemical communication
Behavioral Interaction
Edge
Vertex

Materials Required:
Ants marked with paint so as to be told apart
Petri dish for staging ant fights
Paper
Pencil
Graph of middle school interactions
Whiteboard

Preparation:
To prepare for this lesson, we had the students keep track of their social interactions with each other during passing periods for one day. We took that data and created a graph that represented the data. We also had to acquire ants and paint the top of their heads, so the student can distinguish them apart.

Safety:
Certain species of ants may bite or sting. Ants should be kept in closed Petri dishes to prevent escape.

METHOD: 5 E'S MODEL

Describe the step-by-step procedures for each E of the 5 E's model:

Engage:

Students have already been exposed to ants and the behavioral feedback loops, which reinforce certain activities on behalf of the group. Videos of ants and some of their more interesting and complicated behaviors can be shown to remind students about how these ants can perform complicated actions in response to chemical cues.

Explore:
Students will be placed into groups of 2 or 3. Each group with get an ant 'arena' (Petri dish) with about 8 ants in each dish. For 3 minutes, the students will observe the interactions of the ants. Each time that an ant interacts with another ant (touches with antennae), the students will put a tally on their paper. The ants need to have distinguishing markings (in this case their heads will be colored) so the students will know which ants are interacting.

Explain:
After the data has been collected, the Resident Mathematician (RM) will teach them how to create a graph with their data. Each ant will be represented by a vertex on the graph and each time two ants touch during the observation period, another edge will be added between their corresponding vertices. After the graph has been created, the RS will help them recall facts about the social behavior of ants. Next both RM and RS will lead a discussion about the graphs they have created. This discussion will answer the following questions:
  1. Why is representing this data with a graph advantageous?
 2. What information does the graph give us about social interactions between ants?

Elaborate:
Next, the RS and RM will remind the students to kept track of their own social interactions a couple weeks ago. The RS will then put a subgraph from that data on the board.

Evaluate:
In the last few minutes, the students will answer the following two questions and hand it in:
  1. In your own words, describe the difference between human and ant social interactions.
  2. How did we use graphs to better understand social interactions?
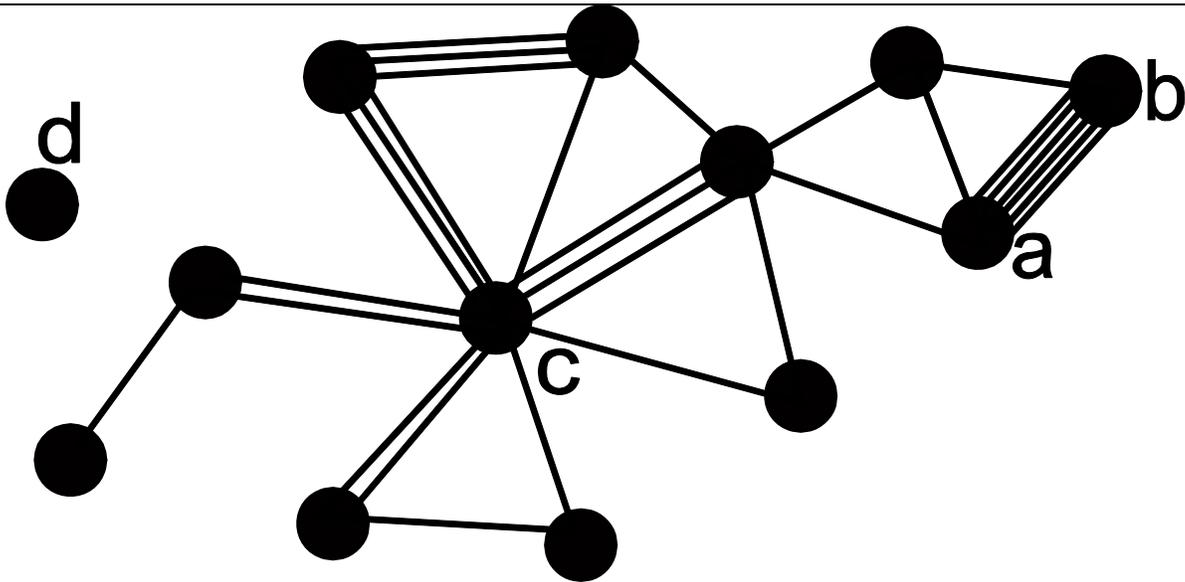
We will then have a discussion about the graph above:
1. What can you say about the relationship between a and b?
2. Who is your best guess for vertex c?
3. What can be said about vertex d?
4. How is this graph different the graph we created about the ants?

Finally, the RS will lead a discussion about the differences in social interactions between ants and humans.

ADAPTATIONS OR DIFFERENTIATED LEARNING

Students will be grouped strategically to optimize time on task.

EXTENSIONS & CONNECTIONS

Gifted students will be challenged to create a social interaction graph for other species based on information they have learned in science.

HANDOUTS & PRESENTATIONS

There are no handouts or slides.

PEER REVIEW COMMENTS

This lesson was developed in a Transforming Experiences Learning Community meeting with Mike Greene and Mike Ferrara.

REFLECTIONS (COMPLETED AFTER LESSON IS IMPLEMENTED]

This lesson gave students a glimpse into research on ants and graphs. The students were able to observe and document the behavior of ants, which is much of what an ant researcher does. Furthermore, they created and interpreted graphs, which is much of what a graph theorist does. In these ways, the students got some great insight into the world of mathematics and science. Overall, it was a great lesson.

If we were to do the lesson again, we would make a few changes. First we would not do the lesson on the last full day of school. Although the students did well, there was much distraction (locker cleanout in the hall, signing of shirts, ect). In the first few classes we had them look at the graph of the ant interactions before the graph of the student interactions. However, in retrospect we would reverse that order. It seemed easier for them to look at the student graph and infer information (vertex a and b are best friends, etc.). After discussing the student graph, it was easier for them to contrast that graph with the ant graph.

Students clearly understood what was expected of them and made graphs of the ant interactions that clearly illustrated the diffuse nature of social insect interactions. This was easily contrasted with the more clustered interactions depicted on the graph of the students' interactions. Some students made the connection between the information described by each graph and the fact that different species have very different modes of social interaction and that these differences become evident when structured in a graphic fashion.

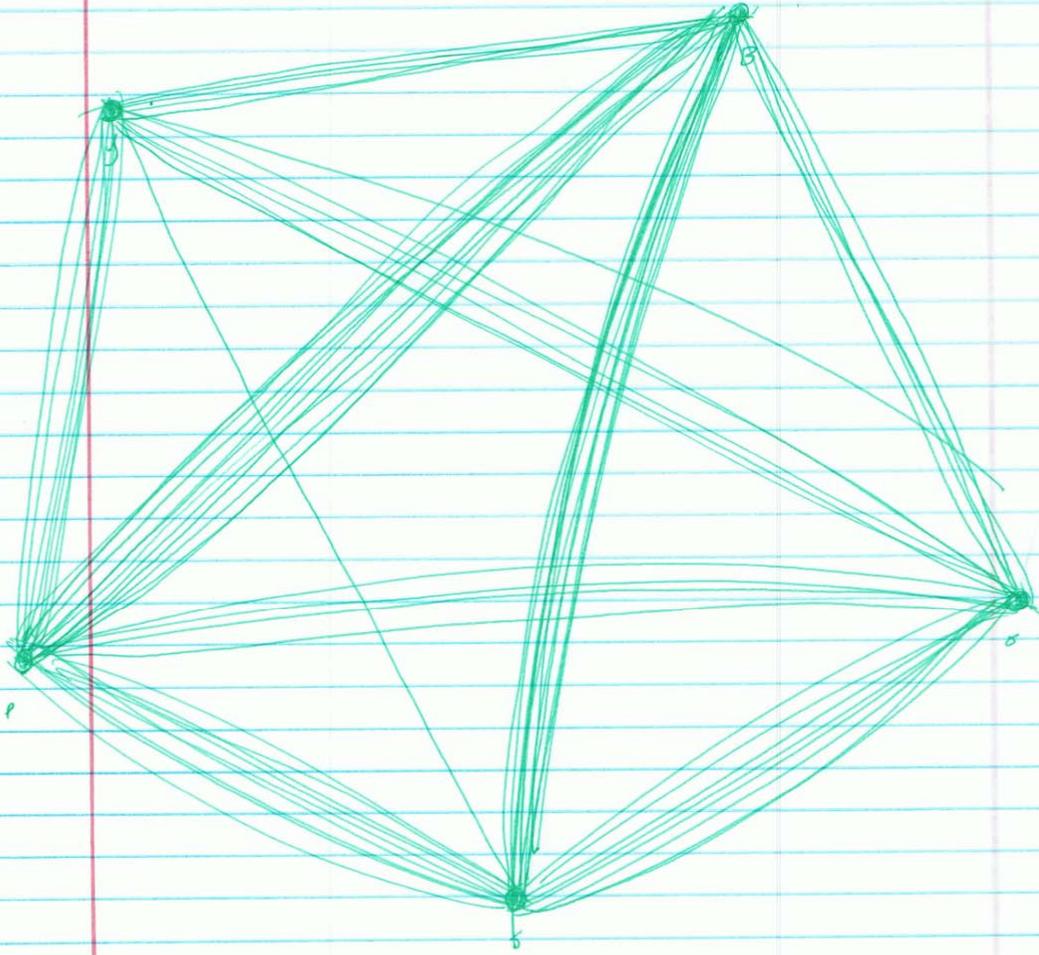**STUDENT WORK EXAMPLES** (COMPLETED AFTER LESSON IS IMPLEMENTED]

ant interactions

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Humans ~~are~~ interact
differently than ants. Humans
form bonds, heirarchys, whereas
ants do not. Ants interact equally
amongst themselves.

Yellow Ants

Ants