Integrating Math in a Sea of Science

Fourth-grade students learn through a fishy feeding frenzy!

By Julie Herron and Andrea Foster

Most elementary science teachers know that the key to engaging students' interest in science is to design learning experiences that are hands-on, minds-on, collaborative, and fun. However, while creating these engaging science activities, they often overlook the potential to develop significant mathematical concepts and skills in tandem with the learning experience. Too often, topics in mathematics and science are touched upon at surface level but not addressed or developed in much depth. Content coverage, rather than the provision of contextual understanding, has been the valued mode in mathematics and science teaching. For these reasons, science and mathematics can be integrated to make both disciplines relevant and meaningful to the learner. Mathematics, when integrated with science, provides the opportunity for students to apply the discipline to real situations that are relevant to the student's world and presented from the student's own perspective (Furner and Kumar 2007; Brown 2004; Davison, Miller, and Metheny 1995). We want our elementary science teachers and their students to move beyond "channel surfing," and knowing just enough to be dangerous, to go deep and experience the many and often rich natural connections between science and mathematics. Mathematics is the foundation of science. The two are inseparable.

In our featured lesson, entitled "Fishy Feeding Frenzy," we engage fourth-grade students in a classic science activity that requires them to experience the interdependent relationships of organisms in an ecosystem. The children simulate the survival of four types of fish and one whale: (1) toothpick fish who spears its food; (2) chopstick fish who picks up its food; (3) straw fish who "sucks up" its food; (4) clothespin fish that crunches its food; and (5) a baleen whale whose baleen, which is represented by a strainer, filters its food. These animals, with their specialized mouth parts, compete for food resources in an ocean habitat (see Table 1).

The students explore how adaptations increase the survival of a member of a species by participating in an active "fishy feeding frenzy." Each student selects a unique mouth part with which to gather four food sources (with items representing fish, plankton, worms, and mollusks) in an aquatic ecosystem. The object of the activity is to gather as much food as possible to stay alive. At the end of each round, students record their data on a chart. By the end of the activity, students should be able to answer the following question: *Which fish, with its unique feeding structure in this ecosystem, is best suited for a habitat of smaller fish, plankton, worms, and mollusks?*

CAUTION

Children should be provided with safe and appropriate eye protection (safety goggles) during the frenzy, especially while using sharp objects such as toothpicks and chopsticks to gather food items. In addition, because of some possible food allergies and sugar restrictions, nonconsumable materials can be used to replace the food in this activity. For example, marbles can be used for mollusks, paper clips for plankton, rubber bands for worms, and toy fish for fish. Teachers should be cautious of possible choking hazards with food/nonfood items—students must not eat during the activity.

TABLE 1.

Table illustrating the comparisons of simulation representations to the natural world.

Type of Mouth Representation	Example of Species in the Natural World	Natural World Food Source	Food Representations
Strainer	Humpback and other baleen whales, filter deeders	Plankton	Popcorn
Toothpick	Butterfly fish, swordfish	Fish, worms	Fish crackers, gummy worms
Clothespin	Piranha, barracuda, walleye, parrot fish, horn sharks	Fish, worms, mollusks	Fish crackers, gummy worms, peanut M&M's
Straw	Sea horse, *plecostomus* (sucker fish), grouper	Small fish, worms, plankton	Fish crackers, gummy worms, popcorn
Chopstick	Sea bass, flounder	Mollusks, plankton, worms, fish	Peanut M&M's, popcorn, gummy worms, fish crackers

FIGURE 1.

Materials

For five groups of five students (fish):

- blue poster board (laminated)
- plastic cups (stomach)
- sandwich size plastic bags (to store data)
- types of fish mouths:
  - o clothespins (piranha)
  - o toothpicks (swordfish)
  - o straws (plecostomus or flounder)
  - o chopsticks (sea bass)
  - o strainer (baleen whale)
- *Food Sources:
  - o fish crackers – small fish
  - o gummi worms – worms
  - o peanut M&M's – mollusks
  - o popcorn – plankton

The Fishy Feeding Frenzy Activity

The fishy feeding frenzy lesson addresses *Next Generation Science Standards* (*NGSS*) as students compete for survival within an ecosystem while exploring structure and function of given organisms. The optimal ecosystem would have five students each with a different mouth part. However, in this lesson we established an "ecosystem" of four students. This resulted in slightly different data than if all five adaptations were represented in the groups. A different food source is placed on the table for each round.

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Students simulate ways fish obtain food.

Students must collect the food sources and store their collected food in a "tummy," or plastic cup (see Figure 1 for materials needed). When the round ends, students count their food items, record the number, and store the food in their data collection bag for later consumption. Emphasis should be on the students' careful collection and recording of data.

To engage students in this lesson, show students pictures of a piranha and goldfish. Ask students to tell the similarities they see (body shape, fins, eyes, mouth, tail, and so on) and differences (size, teeth) between the two fish species. We incorporated the following guiding questions: What do you notice about the mouth adaptations? What do piranhas eat? What do goldfish eat? Can a goldfish eat the same food as a piranha? Why or why not? One major observation that students comment about is the piranha's sharp teeth. Students infer that piranhas are meat eaters because of their sharp teeth. On the other hand, "Goldfish need to be fed fish flakes," and students make a motion of shaking the flakes into a fishbowl.

Once students have selected a mouth part, they get their "stomach" (a plastic cup) and their data bag (a plastic sandwich). Then they are ready to record; the exploration can begin. First, review "The Rules":

1. There are four feeding rounds.
2. You must get food to stay alive.
3. You must have one hand behind your back and the other holds your mouth part.
4. You may not steal food if it is in the animal's stomach (cup).
5. You may cooperate with each other, or not.
6. You must count and record the number of food items collected after each round.

Where the Math Lives

The fishy frenzy has several opportunities for mathematics concepts to come to the forefront of science learning by using the *Common Core* Data Analysis standards as well as the Mathematical Practices. The first point of mathematics integration occurs prior to the frenzy activity, when students begin the process of developing questions for data collection. It occurs again immediately following the activity when students will look at their table data. The more robust mathematics will follow the next day when the students have the opportunity to further explore both their table data and whole-class data.

Day 1: Prior to the Frenzy...

The *Common Core* Mathematics Standards ask for students to "recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers" (NGAC and CCSSO 2010). It is important to note that the *Common Core* standards that correspond with this activity are above the fourth-grade level; however, the students in this class were ready for the challenge. In table groups, students discussed the different adaptations and predicted the possible data outcomes. Based upon their predictions, each group came up with one or two questions that addressed the data they will be collecting. For example, table one had a great debate as to how the straw fish would be able to pick up anything. "You either have to stab the food or suck it up with your straw," stated one student. After the debate, the teachers further probed the table to think about how this adaptation may affect the data. "Do you think the straw fish will be a successful eater? If so, what does a successful eater mean to you? If not, why might the straw fish be unsuccessful?" Each table shared and posted their statistical questions and the reasoning behind them. Here are some group-generated questions prior to the activity that went beyond "who eats the most":

- Will there be a hungry fish?
- Does each fish eat enough food for its body size?
- Do any of the fish eat the same amount of food? Why would that happen?
- Which is the preferred food by the fish?


Students place food sources in their "stomach," or plastic cup.

After the students shared their statistical questions, the class discussed the similarities and differences. The questions were written on a poster and hung on the wall to refer to throughout the lesson. We then launched into the fishy feeding frenzy to discover the answers to our statistical questions.

Taking a First Pass at the Data

Once the students collected their data, we had the groups take a first pass at the table data. Below are the series of questions that we asked the students, which prompted them to think deeper about the data.

- What did they notice? What was the range of the data?
- According to the data, which fish was most successful? Least successful? Why?
- According to the data, did a certain type of food have an effect on the data? Why?
- What do they think the shape of table data distribution will look like?

We had the students define what is successful. They agreed that it means the fish ate "a lot" of food. As the students were working through the questions, they recorded their findings. Here are some of the findings from the students: "All the 'stomachs' (data collection bags) had some food in it." "The amount of food in the stomachs was different in each group and across the class." When discussing which type of food had an effect on the data, the students responded, "The mollusk (M&M's) messed with the data because they were hard to get." The class discussed the key finding from every table. At this point, the lesson wrapped up for the day. However, the students were asked to be thinking about what type of graph would represent their data.

Day 2: Data Analysis

Day 2 dives deeper into the Data Analysis standards by having the students explore data in Excel spreadsheets. Please note, the students did not do the statistical calculations; they simply explored what the class data looks like represented in different graphs. There was some prep work required by the teacher for this day to be successful. The teacher collected the table data and created an Excel spreadsheet of the class data. The spreadsheet had all of the data for each fish together. Each fish is represented on the y-axis (down the left) and each type of food is across the x-axis (across the bottom). This way all the data for each fish is together, which facilitates the students moving beyond bar graphs when working with data. It is also important to note that Excel refers to all graphical representation as charts.

Starting on the Sandbar

We revisited the question, "What type of graph do you think best represents your data?" The table groups discussed various types of graphs (bar, line, circle, etc.). All of the students but one chose to represent the data with a bar graph. However, about a quarter of the students graphed the total amount of food consumed, while the rest of the class graphed the amount consumed of each type of food for each fish at the table. When discussing the different reasons to graph the total versus each food, a student stated, "This showed me who is the most successful fish." Then another student pressed him, "But that doesn't show which fish is the most successful with which type of food. It doesn't give enough information." This interaction became a discussion point for the whole class, which provided a very rich conversation and allowed for the teachers to address the *Common Core* Mathematic Practice 2 as well develop the science idea that the strength of a conclusion is derived from data in an investigation. This demonstrates how understanding the best way to display data mathematically informs scientific conclusions. Once we wrapped up the bar graph discussion, we dove deeper into our data set.

Diving Deep

We had the students pick up their Chromebooks with the class data in an Excel spreadsheet to get started on this final part of the project. As a note, this activity can be done with any technology that has access to Excel. The students worked in pairs during the final phase of data analysis. Students individually record their thoughts about the best representation of the data throughout this phase of the data analysis.

First, we explored bar graphs that represented the whole-class data. In pairs, the students discussed whether

TABLE 2.

Fishy Feeding Frenzy rubric.

Score	Mathematical Thinking	Communication	Science Concepts
4 Whale	I accurately represented the data from my table and the whole class. I am able to justify my reasoning for the table and the whole class with the data.	I am able to share my conclusions with my table and the whole class. I can explain about how my table and whole-class data informed my conclusions.	I get it! Animals have structures that affect their survival.
3 Shark	I accurately represented the data from my table or the whole class. I am able to justify my reasoning for the table or the whole class with the data.	I am able to share my conclusions with my table or the whole class. I can explain about how my table or whole-class data informed my conclusions.	I get most of it. Animals have structures that affect their survival.
2 Guppy	I represented the data from my table or the whole class with a few errors. I am able to justify my reasoning with some data.	I am able to share some of my conclusions with my table or the whole class. I can somewhat explain about how my table and whole-class data informed my conclusions.	I get some of it. Animals have structures that affect their survival.
1 Catfish	I represented the data from my table or the whole class with errors. I am unable to justify my reasoning with the data.	I am unable to share my conclusions with my table or the whole class. I can explain about how my table or whole-class data informed my conclusions.	I don't yet fully understand that animals have structures that affect their survival.

a cluster or stacked bar graph best represented the data and why. The students also examined the difference between column charts (vertical bar graph) versus bar charts (horizontal bar graphs). Some of the students felt that the bar cluster graph was the best representation of the data. "I like the bar cluster graph because I see the differences in the data better. It is all separated out and that helps," stated one student. While other students preferred the stacked column graphs for the same reason, they thought they could see the data better in a stacked format. As the students were exploring the different graphic representations, we revisited the guiding questions from Day 1. The outlier in the data set became very apparent once we started working with the graphs. The students were not familiar with the term *outlier*; however, the data shown provided a good example that helped them understand the meaning. We discussed the term and what it means in data, particularly in this data. They wanted to know how one chopstick fish was able to eat so much. Through the discussion, it was revealed that a student put a rubber band on the end of her chopsticks to help her use them more effectively. She stated, "That's what I do when I eat sushi." Learning that a student further adapted her fish prompted an unintended discussion about adaptations and the role of outliers in a data set.

After the bar graphs, the students explored the class data with line graphs. The students compared line graphs by using line graphs with markers, stacked line graphs, and stacked line graphs with markers. Overall, the students felt that the line graphs didn't really show what was happening with the data. "It is hard to figure out which fish ate the most," stated one pair. Another pair said, "I am not sure what this graph is telling me." At this point, we reminded the students that "a graph should be telling a story about the data." This prompted the discussion about which representation they thought was the best representation of the data and why.

Last, we explored how the data looked on scatterplots. While this is not a fourth-grade math standard, it was a great opportunity to introduce the student data in a different representation. At first, the students thought the scatterplots really didn't tell them anything about the data. "It is just a bunch of dots on the page," stated one student. Then we demonstrated how to add the trend lines for each type of food using the trend line command in Excel. Trend lines are general tendency of something in a data set. Surprisingly, the mollusk showed the only positive trend line. The students discussed the different adaptations of the fish, how the adaptations of the fish affect its ability to get food, and how certain fish should live in the same ecosystem with their appropriate food type. Overall, the data pattern from the class mirrored the natural world (See Table 1). However, there were a few ecosystems (tables) where symbiotic relationships influenced the data, meaning some fish helped other fish to get food. For example, the whale would scoop food so that the strawfish could easily retrieve food from the whale's mouth.

Wrapping Up the Frenzy

This lesson demonstrates how math can come to life in science teaching. Students can self-assess using Fishy Feeding Frenzy rubric (Table 2). This rubric will provide an overall assessment of mathematical thinking, communication skills, and science conceptual understanding. Furthermore, it is important to help teachers figure out where math and science swim together, which will afford science teaching to break through to the forefront of the elementary classroom. If teachers see how the math lives in science, there will be more opportunities for science to live in the elementary classroom. ■

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This activity was inspired by and adapted from the Bird Beak Buffet Activity (*www.projectwild.org/growingupwild/Bird_Beak_Buffet.pdf*).

References

Brown, S. 2004. Integrating math and science: The good, the bad, and the chaotic. *Classroom Leadership* 7 (6). *www.ascd.org/publications/classroom-leadership/mar2004/Integrating-Math-and-Science.aspx*.

Davison, D., K. Miller, and D. Metheny. 1995. What does the integration of science and mathematics really mean? *School Science and Mathematics* 95 (5): 226–230.

Furner, J.M., and D.D. Kumar. 2007. The mathematics and science integration argument: A stand for teacher education. *Eurasia Journal of Mathematics, Science & Technology Education* 3 (3): 185–189.

National Governors Association Center for Best Practices and Council of Chief State School Officers (NGAC and CCSSO). 2010. *Common core state standards*. Washington, DC: NGAC and CCSSO.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*.Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

Internet Resource

NSTA safety guidelines
www.nsta.org/about/positions/animals.aspx

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013):

4-LS1 From Molecules to Organisms: Structures and Processes

www.nextgenscience.org/dci-arrangement/4-ls1-molecules-organisms-structures-and-processes

The chart below makes one set of connections between the instruction outlined in the article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Performance Expectation	**Connections to Classroom Activity** *Students:*
4-LS1-1. Construct an argument that animals have internal and external structures that function to support survival, growth, behavior, and reproduction.	• analyze data to determine which mouth structures are best suited for survival in an aquatic ecosystem.
Science and Engineering Practices	
Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions	• analyze data to determine the effectiveness of each model within the small- and whole-group system. • construct explanations based on analyzed data to determine which food source and ecosystem is best for each adaptation.
Disciplinary Core Idea	
LS1.A: Structure and Function • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.	• compare and contrast mouth parts to determine which structures are suitable for survival.
Crosscutting Concepts	
Systems and System Models	• use mouth part models to explore how organisms survive within an ecosystem. • record and share data to describe the survival of each organism within the ecosystem.

Connections to the *Common Core State Standards* (NGAC and CCSSO 2010):

CCSS.Math

6. SP. A.1

Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.

6. SP. A. 2

Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

Common Core Mathematical Practices

- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics.
- Use appropriate tools strategically.
- Attend to precision.