Animal Locomotion Trial Run at El Sausal

Analysis of pre and post tests by Kevin Miklasz

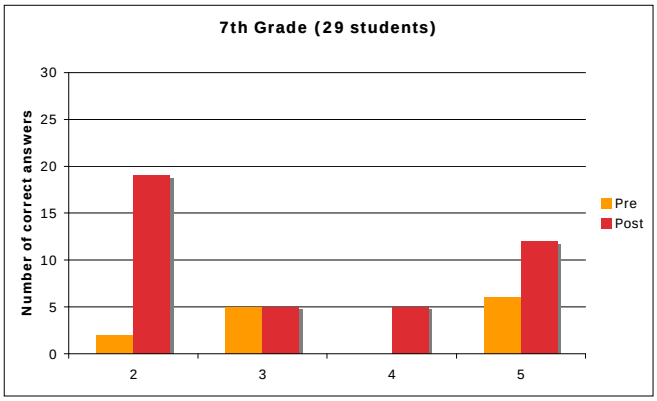
PROGRAM DESCRIPTION

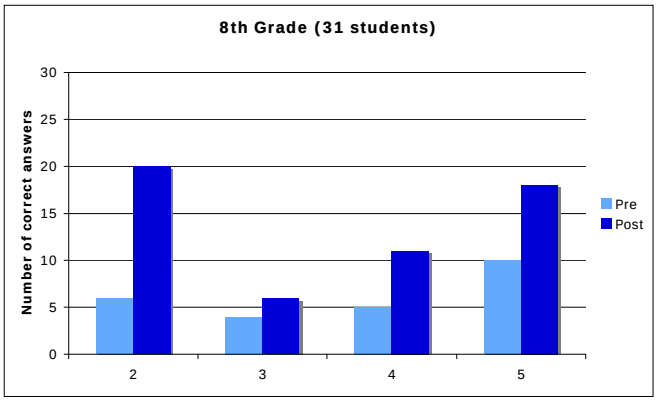
We conducted a three lesson course for a 7th and 8th grade class (59 students total). The topic was animal locomotion, the intent of the course is to teach students about the physics of animals movement, leading up to the concept of Reynolds number. This trial run only covered the first three lessons (gravity, buoyancy, and viscosity). The course was tested with both 7th and 8th graders to see how conducive the material was to both groups. In this school district, students learned biology in 7th grade, and chemistry and physics in 8th grade. This course was conducted in the fall, so neither group had received any formal physics, but the 8th graders had taken biology and some chemistry. The 7th graders had just finished cell biology. The course was designed and taught by graduate students and research technicians at Hopkins Marine Station of Stanford University with help from Iridescent, a science education nonprofit.

Students learned about each topic in a 50 min. class, which began with a short lecture followed by an activity.

- **Gravity** - Students learned about center of gravity and balance, and how it related to gliding animals. Students first balanced pre-made cutouts of gliders, and then had to cut out and balance their own shapes.
- **Buoyancy (Density)** – Students learned about density, and how it varied for different fluids and objects. Students had to make a neutral buoyancy "fish" by adding relatively dense or light materials to a base model.
- **Viscosity** – Students learned about drag and viscosity and how it related to plankton. Students then made plankton models from plastic golf balls and pipe cleaners that had to sink in the water as slow as possible.

Students were given a pre and post test to gauge the misconceptions that students have about these topics, and if we were able to adjust their misconceptions as part of this course. Results for both grades can be seen in the graphs below:





A copy of the pre and post test is available here: http://iridescentlearning.org/joomla/images/stories/forEducators/animallocomotionpre-assessment.pdf

IDEAS ABOUT SCIENCE AND ENGINEERING

The first question tests out the idea of "priming" student for tests. If students think about how a scientist would answer questions before answering them, are the students more likely to answer the questions like a scientist? At this point we are just testing out possible questions to use. Some other questions that have been used- *"How would an intelligent person answer these questions?"* and *"What do you like about science?"* The question used here *"What do you think you should do to become a scientist or engineer?"* yielded some interesting answers!

Go to college, Get a degree (most common)

7th- I think you have to go to college and get a master's on it

7th - I think I should go to college and study science

8th - Go to college

8th - Go to engineer school at Monteray

8th - You need to go to college and get a degree

8th - I think I should get good grades in school and then save up money to go to college so I could get my master's degree and then I could studie the earth

Study a lot

7th - I think you should first like science and need to study a lot

7th - You need to know about gravity, mass, and density

7th - You must study hard and know a lot about microscopes

7th - I think I should pay more attention in science and also study science when I go to college

8th - Study a lot and read a lot of science books

8th - You should study and work hard at school

8th - Pay very close attention in science because I am pretty sure that if you want to be a scientist or engineer you need to know some things that were learning

Others

7th - They should know math

7th - I think you should know a lot about animals and wat they are and what they do

7th - To become a scientist or engineer I have to know my physics

7th - I think I should study and enhance our brains with literature

8th - You should do your research and love math

8th - I believe I must go to college. You must also like math. And probably be a kenestetic learner because they like doing things with their hands, experiments.

8th - Know about movements and be prepared and know about nature

8th - Well I don't really want to be those things, but if I were to be I'd be a scientist because it is a neat job you get to experiment with stuff and all of that and find cures for certain diseases

CONTENT KNOWLEDGE

Testing Gravity

Students answered the question *"In which direction does gravity act on the following animals? Mark with an arrow."* On the pretest, students often drew arrows in every direction, sometimes circling one of the animals, or drawing curved arrows. They did not seem to know how to answer this question. On the exit interviews after the first and second session, we asked them to answer similar questions, and noticed that this was something they were still having trouble with. We practiced drawing free-body diagrams in class, and also reviewed gravity with them at the beginning of the second and third sessions. This repetitive technique seemed to work well, we saw drastic improvements in both classes in the post-test. Approaching this questions from multiple angles (objects falling, objects sitting on a table) and repetition seemed to work best. Perhaps this repetitive review will also help with the other concepts when we do our full 6-7 lesson course.

Suggestions for Improvement

The activity was a bit short. I think the activity was still useful, but we need to structure it a bit more. The 8th grade class was a bored after about 10 minutes, but seemed to enjoy cutting out shapes. For the 7th grade class, we extended the lecture time, and told them to balance 3 shapes before then cutting out one of their own. This seemed to fill up the time better. We also have plenty of time to give out the pre-assessment on this first day, instead of beforehand.

Testing Buoyancy (Density)

Buoyancy was a tough concept to teach to students. We tried to teach the term to the 8th graders, who had seen density before in their chemistry class, but for the 7th graders we only phrased everything in terms of density. It did not seem to affect their understanding of how to do the activity. We taught density as mass over volume, or how packed together the molecules in an object are. We taught buoyancy as the relative density of an object compared to the density of the fluid that the object is in.

We tested the students knowledge of buoyancy with two questions- *"Why does a helium-filled balloon rise through the air?"* and *"A piece of wood will fall through the air but float on water. Why does this happen?"*

Answers

A few student were able to answer the balloon question correctly in the pre-assessment:

7th - Because helium is a light gas

7th - Because the helium is lighter than oxygen

8th - It rises through the air because it's less dense than the air

Many references were made to the balloon having air in it, with little explanation of why that made the balloon rise

8th - Helium is air!!

7th - Because of the air in the balloon

8th - Because it is air and it flies up

In the post assessment, both 7th and 8th graders performed similarly in their answers to the balloon question. The 8th grade class did better on the wood question than the 7th grade class, but both classes showed significant improvement on this question.

Misconceptions- strength of air

Many students had the right idea about the helium gas being different in some way from normal air, but they often did not know how to express that idea. The students used terms like "special" or "strong" to describe this property they could not put a name on:

8th - Because helium is stronger than air. Also helium molecules bounce everywhere

8th - Because helium is a strong air and can be raised in air

7th - It rises in the air because helium is special

The same thing happened with wood and water

8th - If the wood is in the air it will fall because the air can't take that much wait. if a wood is in the water it floats because the water is strong.

In the post-test, some of these students used the scientific terminology we had given them, like density and gravity, to explain these phenomena, even though their explanations were not always complete or correct.

8th - Because it's packed gas

8th - A helium filled balloon rises through the air because of gravity

7th - Because the density is helping it go up

Misconceptions- chemical reactions

Mostly in the 8th grade class, students said that helium rose because of chemistry:

8TH- Chemical reaction, I think

8TH- It rises because of the chemical reactions it has, and gravity

These answers were even more prominent in the post-tests. I think this was a consequence of teaching this lesson at the same time that their class was going over chemistry.

Misconceptions- Wood sinks!!

This to me was the most interesting misconception. Despite the fact that we told students in the phrasing of the question that wood will float, many did not believe us!

7th - I think no is not going to float on the water because a piece of wood is too heavy to float

8th - A piece of wood wouldn't float because it's a solid

In the pre-test, three 8th graders and one 7th grader answered this way. In the post test, one 8th grader kept their view, while two different 7th graders answered this way.

Misconceptions- there is no gravity

This answer was used both for the balloon and wood, and was a common misconception.

7th - They rise to the air because that don't have gravity

7th - Because there is no gravity in water

Suggestions for Improvement

I think buoyancy and density should be split into two lessons, each topic is complicated enough to deserve its own lesson. Also, there are a quite a few misconceptions here, more time spent going over this material could help clear up some of those misconceptions.

For the activity, I would recommend getting a small container for each pair of students that they could use to test out the density of our test objects on their own. The few testing tanks we had in the class tended to get a bit congested.

Student answers improved on the question about water, but not the one about air. Additionally, students that got one of these questions right did not always get the other question right. Students do not seem to be applying what they learned about water in the activity to explain phenomena in air. More emphasis should be given on what a fluid is, and on the similarity of these principles across air and water.

Testing Viscosity

The question was *"Here's some pictures of plankton, tiny organisms that live in the ocean. These animals spend their time sinking through the water. Which plankton do you think sinks the fastest? Which sinks the slowest?"* In my opinion, this question was not the best question to use to test their knowledge of viscosity. The objects were a bit hard to see, and the objects looked to be different sizes based on the size of the picture on the page, even though in actuality the objects are all the same size. The answer we wanted was that the middle object sank the fastest and the right object the slowest, because the right-most object has the longest spines, which create the most drag. But one student explained:

8th - I think the one (left) because it looks more huge then the other one. This one (right) is the lowest because smaller.

This answer shows good intuition, a smaller object will sink slower than a bigger one, but was not something we were teaching, and was not the answer we were going for. Most students did not provide explanations for their answers, so I don't know how many other students may have also had "wrong" answers but for good reasons. I think we need to phrase this question better.

Despite the possibly ambiguous nature of the question, many students did give the answer we were looking for. The 8th grade class again did better than the 7th grade class, but both classes showed marked improvement between the pre and post test.

Suggestions for Improvement

My only suggestion for improvement would be to expand upon the activity, there tended to be a lot of downtime for the students. Perhaps we could have the students build both a streamlined and draggy shape.

CURRICULUM IMPROVEMENTS

I would suggest offering the following courses for a 6 week course:

1. **Gravity**
2. **Density**
3. **Buoyancy**
4. **Viscosity and Drag**

5. Lift

6. Reynolds number

For a 7 week course, I would suggest breaking viscosity and drag into two separate lessons. The drag lesson would be just like the lesson we taught. The viscosity lesson would be a series of stations, similar to the density lesson.

For the second two lessons, we had the students take notes in their science notebooks. We had them draw free-body diagrams and write down terms. I think we should plan on using these notebooks again, or have them take notes on something similar.

We should review concepts at the beginning of each session. The most important concepts for teaching Reynolds number is buoyancy and viscosity. The last lesson on Reynolds number, should be relatively simple and only review and synthesize topics we have already taught them, since it seems like students need to hear a concept several times before they get it.

We were testing which grade level to do the full lesson with later in the year. Both age groups seemed capable of handling the material. The 8th grade class tended to perform better, but the level of improvement was similar for both classes. The chemistry that the 8th grade class was taking tended to interfere with their thinking, but if we offered this course later in the year they would be going over physics which would be more in line with this course. Still, our course might not match up perfectly with the physics that they are going over, and I am worried about confusing concepts that they are going over in class with what we are teaching. The 7th grade class was going over different topics entirely, and it seemed easier to teach them completely new ideas from scratch. For that reason, I'd suggest going with 7th grade in the future.