

Are we making a difference?

Analysis of pre and post tests from summer program in the Bay Area.

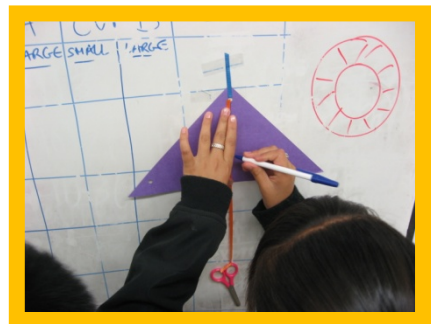
PROGRAM DESCRIPTION: We conducted five-session courses with different groups of 10-12 year old boys and girls (total = 120). The topics were Biomechanics (conducted only with one group of girls) and Heat Transfer and Energy Efficient Houses (conducted with five different groups of boys and girls). Instructors were engineering undergraduate and graduate students from Stanford and USC who were given prepared lesson plans and activities.

Biomechanics: Students learned about gravity, center of gravity, balance, muscles and joints through various demonstrations and activities.

Heat Transfer and Energy Efficient Houses: Students learned about:

- Convection by building energy efficient houses with stack ventilation (and testing design efficiency with incense sticks)
- Conduction by building well-insulated houses and testing which design would protect an ice cube the best from a heat source
- Radiation by building houses with reflective walls and roofs and testing which design would keep an ice cube from melting.

The purpose of the pre and post tests was to gauge what students thought about science and what they already knew about the topic. We share some of the interesting things we observed from their responses.



BELIEFS ABOUT INTELLIGENCE I was very intrigued by two studies mentioned in Malcolm Gladwell's book "Blink".

A group of students prepared to play Trivial Pursuit. One group of students was asked to think about how a professor worked and the other were asked to think about soccer hooligans. Their answers to the trivia questions asked? The Professors: 55.6; The Hooligans: 42. Another interesting study was on black college students taking 20 questions on the GRE. "when students were asked to identify their race on a pretest questionnaire, that simple act was sufficient to prime them with all the negative

stereotypes associated with African Americans and academic achievement – and the number of items they got right was cut *in half*.”

We have been testing the above concept of “priming” out in some of the assessments. We haven’t done a controlled study yet as we are still testing out the questions. But this was the rationale behind asking the first question “*How would an intelligent person answer these questions*” and the students’ responses are very interesting!

Studying, focusing, reading, researching, trying hard

They would take their time and think hard

They would stay focused

They would try their best and use what they can

Reading and comprehending

With a smart thought, they also think of things from the past that they learned

In a very smart way. Write notes and use them.

An intelligent person would answer these questions using common knowledge, making sense, appropriately, specifically and being on the subject.

You explain it, read it and ask it

Thinking of the right answer not just write what ever

They would right what they think is right and if they don’t know the answer they could skip it and go back if there is time

An intelligent person can answer these questions by using books and a computer. You could also use other resources.

Good command of the language. I think this maybe because many teachers encourage students to “document neatly” like scientists do.

An intelligent person would answer in complete sentences

Complete sentences. Confusing words. Proper punctuation.

An intelligent person would answer these questions by stealing the words of the question and using punctuation and by writing neat.

Well answerd and With strong words

Shortly because there intelligent

An intelligent person would sound very sophisticated

Just being intelligent (not in your control)

If youre intelligent you should already know

By its brain

Its easier for them because they have more knowledge of these things. So they would answer them in a more scientific way.

With ease if they knew everything

Interesting and insightful

By telling you wat they will do

Respectfully so I don’t offend someone that has different thoughts

With the truth and with the way they know and thinking for the right answer

ATTITUDE TOWARDS SCIENCE The second question was “What do you like about science?” The rationale behind that question was to do a little bit of “priming” and to find out what students liked about science. Almost all responded positively saying that they loved doing experiments and projects. Many specifically stated that they love learning about atoms, theory of life, space, biology, oceans, earth, zoology, chemicals etc. After the course some changed their statements to include heat, building houses, heat transfer, learning about muscles etc. Some favorites:

PRE

I like how much you learn

It is cool because you get to do weird things

What I like about science is you get to do experiments to see if some thing is true

I like science because you can event stuff

I like that you can use your imagination and create what you want

It is a challenge and it teaches you about a lot of things like astronomy and anatomy and you can do a lot of cool experiments

I like to do experiments and having worksheets for homework

I love the projects and searching thing on the computer

I like science because it is very complex and there are different parts

I like in science that I get the chance to learn about the earth and about myself, and so much more

POST

That you find out stuff you never knew

That you can make things happen

I think the most I like about science is that there is more to learn. Your never done.

you ge to do a lot of fun stuff. You learn new things every day

EVALUATION IMPROVEMENTS It was very surprising to see almost all the students loved doing the experiments and projects. It would be interesting to ask the same question “What do you like about science?” to a range of ages and see the variation (if any) with age.

Also, it would be interesting to add a third question (“What do you think you need to do to become a scientist or an engineer?”) to the above two (“How do you think an intelligent person would answer these questions?”, “What do you like about science?”).

CONTENT KNOWLEDGE

Some findings about students’ understanding on the two topics were as follows:

STUDENTS HAVE THEORIES OF THEIR OWN TO EXPLAIN PHENOMENA AROUND THEM AND THESE THEORIES ARE HARD TO DISPLACE.

However, they do try and reconcile them with the new information, sometimes with interesting results.

Q. What do you think a breakdancer needs to be able to stand on one hand?

PRE: I think he needs to drink a lot of water and eat a lot of fruits and veggies.

POST: I think a breakdancer needs to exercise its muscles and drink a lot of milk

POST: A breakdancer needs a lot of balance to stay on one hand he would also need the center of gravity

Q. Why do you think the metal soup spoon gets hot, but the bowl doesn't get as hot?

POST: the atoms are making the hotness bump into the spoon

POST: the soup conducts the metal spoon because the soup is hot and attracted to the metal

Q. Why do you think you wear a white T-shirt instead of a black one on a hot day?

PRE: black makes you hotter just like polar bears. Polar bears have black skin but white fur

POST: black t shirts preduce heat and white T-shirts don't. Ex: Polar bears like to be in cold because their fur is white but their skin is black

DEMOS AND ANALOGIES ARE VERY POWERFUL

To introduce conduction, a few students are asked to line up according to height and link their elbows. The instructor gently pushes on a student at one end of the line and the class observes all the students in that chain being pushed. This models a good conductor. The students then hold hands and the instructor pushes on the student at the end. This time the push is not conducted as well. This models a semi-conductor and so on... This demonstration was very effective and a few students used the same analogy to explain their thinking.

because the metal spoon has a lot of atoms there arms are really tight and linked

metal spoon gets hot because of the atoms. The bowl doesn't get as hot because the atoms aren't linked

COMMON MISCONCEPTIONS

Metals and dark objects "ATTRACT" heat.

white recfix while black consumes the razes of the sun

INTERESTING EXPLANATIONS

because the temperature from the soup switches places with the spoon

because the atoms are pushing the heat to the coldest place

because the sun reflects on pigments and white has none and black has all of them

CURRICULA IMPROVEMENTS

CONVECTION: The convection experiments worked the best. Students started off with little or no understanding of the need for stack ventilation in a house and after the experiment, there is ~ 40% increase in the number of students connecting that hot air rises and so it is better to put windows and exhaust fans close to the ceilings. However, they do not understand why hot air rises and cold air descends. We need to work on making that connection stronger maybe through some quick demo activities before the students start building the houses.

CONDUCTION: the demo with students linking arms and modeling conductors, semi-conductors and insulators is very powerful, but the experiment is not as clear or direct as the convection one. More time has to be spent on helping the students connect to real world phenomena (eg: the insulating properties of trapped air in woolen sweaters).

GRAVITY: There is a significant increase in understanding that gravity always pulls things to the ground (regardless of whether they are flying or jumping), but we have to check for a true understanding of gravity (which I'm sure millions of adults don't have either).

CHANGE IN CONTENT KNOWLEDGE

Name Tania School _____ Grade _____ Date _____

BIOMECHANICS

1. How do you think a really smart person would answer these questions?

I think that they have to remember what they did.

2. Can you find the center of these objects? Please mark it with a big X.



3. In which direction do you think gravity acts on the runner and the sparrow? Show using arrows.

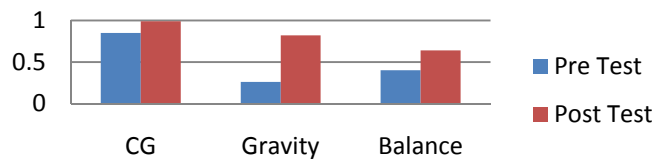


4. What do you think a breakdancer needs to be able to stand on one hand?

I think that they need balance



**Biomechanics, 10 yr girls,
N = 25**





Building the Coolest House!

What do you know?

1. How would an intelligent person answer these questions?

An intelligent person would answer these questions in complete sentences and they would check over the answers when they're done.

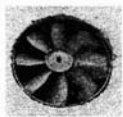


2. What do you like about science?

I like to learn about convection and Atoms.

3. You want to keep your house cool on a hot summer day. Where would you put the exhaust fan (a fan that pushes air from inside to the outside)? Check **your** choice:

- Near the roof
 In the middle of the wall
 Near the floor



Why would you put it there? so that the cold air will sink faster because it's more dense.

4. It is a cold day. What would ~~you~~ make you feel warmer? A woolen sweater or a shirt? Why do you think that?

a woolen sweater because it's a better insulator.



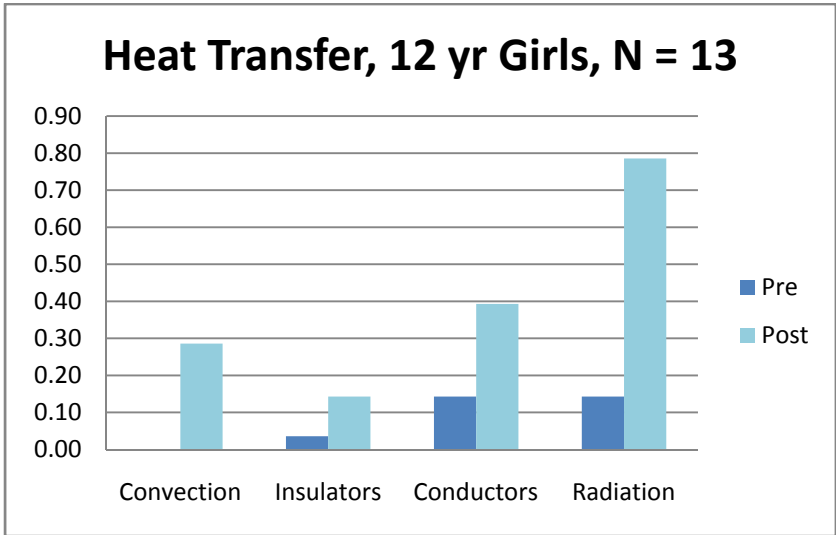
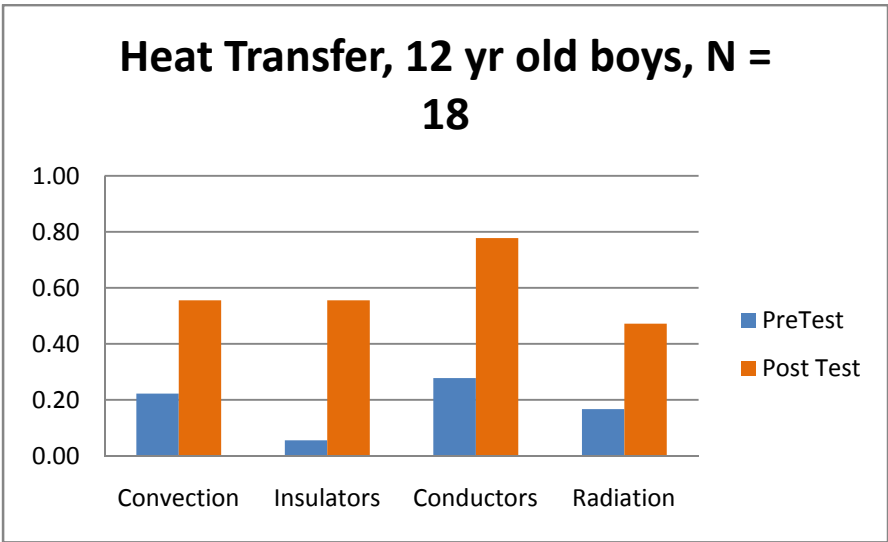
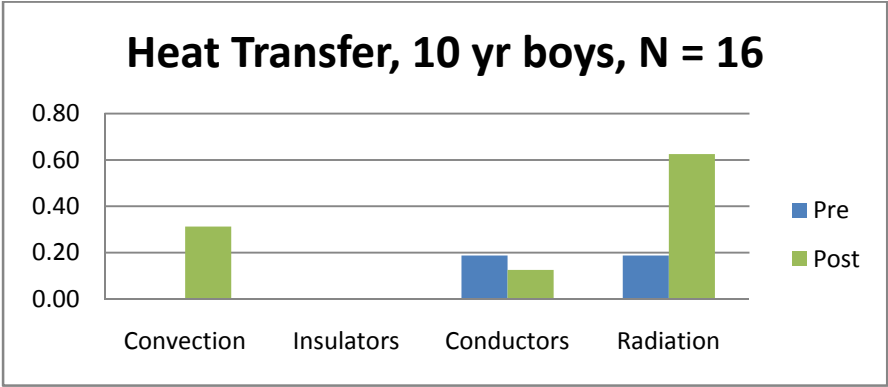
5. Why do you think the metal soup spoon gets hot, but the bowl doesn't get as hot?

The spoon is a metal and metals absorb heat but the bowl doesn't.

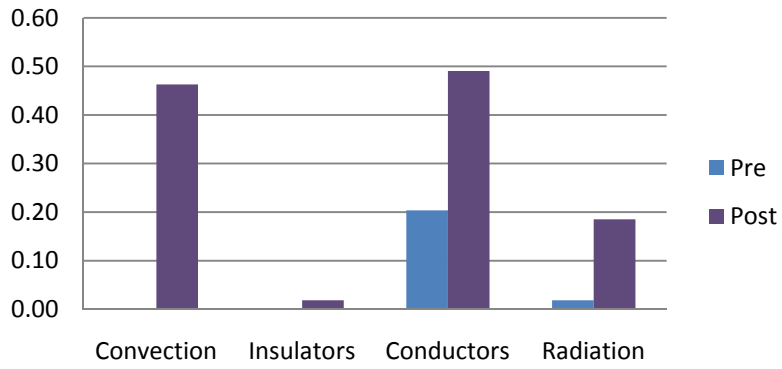
6. Why do you think you wear a white T-shirt instead of a black one on a hot day?

I would wear a white T-shirt because a black shirt would absorb more heat.





Heat Transfer, 11 Yr Girls, N = 27



Heat Transfer, 11 Yr Boys, N = 19

