Teaching Philosophy

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Notecards

On the notecards provided, answer the following two questions:

My biggest success teaching a physics class has come when I…

The biggest problem that I have when I teach a physics class is…

Teaching Philosophy

A book called “How People Learn” was published by the Committee on Developments in Science Learning (NRC) in 2000.

Some of it’s key findings include:

“Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.”

Teaching Philosophy

Another key finding was that:

"A 'metacognitive' approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them."

A recommendation to designing class given was:

"Formative assessments - ongoing assessments designed to make students' thinking visible to both teachers and students - are essential. They permit the teacher to grasp the students' preconceptions, understand where the students are in the 'developmental corridor' from informal to formal thinking, and design instruction accordingly…"

Teaching Philosophy

I had taught for many years and various places before reading this document:

UC Davis, 2000 to 2005
American River College, 2004 to 2006
UC San Diego, 2006 to present

This text synthesized a lot of the issues that I had observed with my teaching experiences.

The things that I would develop a work around that I thought only I noticed now had an explanation and a reasonable course of action to proceed with.

All of this lead to an enlightenment in terms of what I needed to do to refine my teaching.

Anti-Constructivism

The Montillation of Traxoline

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is montilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then brachter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future of our zionter lescelidge.

Directions: Answer the following questions in complete sentences. Be sure to use your best handwriting.

1. What is traxoline?
2. Where is traxoline montilled?
3. How is traxoline quaselled?
4. Why is it important to know about traxoline?

Constructivism

The key to constructivist teaching is have great lab or lecture activities that help students become model builders.

Another key step is then have them explain this model to other students in either a small group setting or as a presentation to the entire class.

Verbalizing their model of the universe (or their model for a particular situation) helps the students to confront their physical impossibilities of their models (or in essence, their misconceptions).

The ultimate goal of constructivism is for the students to become epistemological.

This type of self-reflection is rarely done without prompting.

Constructivism

"I think, however, that there isn't any solution to this problem of education other than to realize that the best teaching can be done only when there is a direct individual relationship between a student and a good teacher--a situation in which the student discusses the ideas, thinks about the things, and talks about the things. It's impossible to learn very much by simply sitting in a lecture, or even by simply doing problems that are assigned. But in our modern times we have so many students to teach that we have to try to find some substitute for the ideal. ..."

--Richard Feynman in the Preface to The Feynman Lectures on Physics, 1963

Active Learning

With my colleagues at UCSD, we started developing a set of tenets that applied to our various forms of teaching.

The base ideas in teaching in this manner are always the same but you adjust either the subject matter or the level of mathematics based upon what you are teaching.

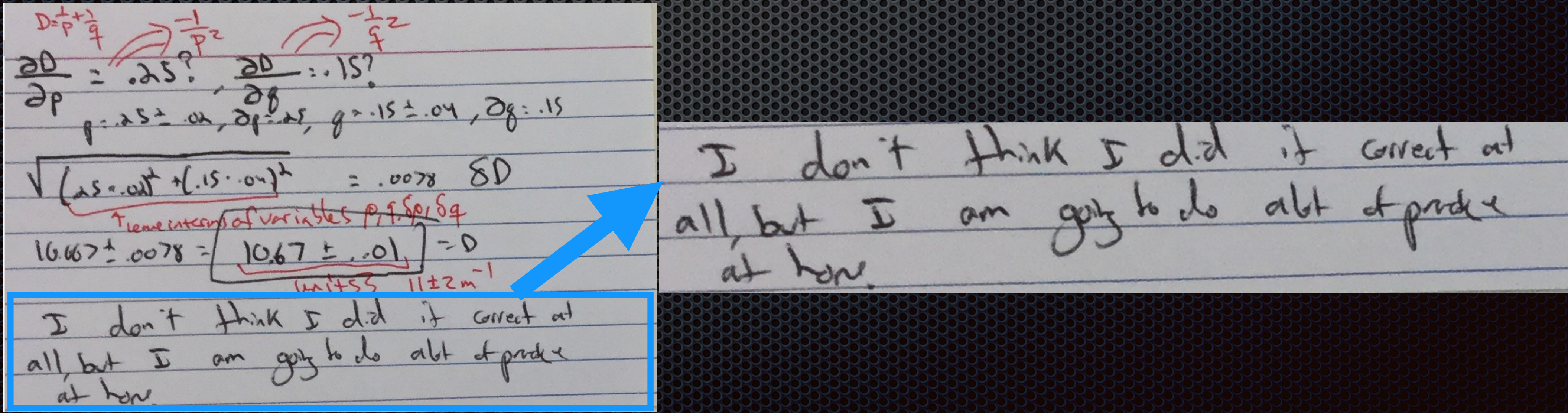
No technique that we incorporated was entirely unique on its own, but bringing everything together in an environment with lecture class sizes of 300+ students and training dozens of lab TAs was.

Active Learning

1. Provide feedback to the students on a regular basis (ideally multiple times per week).

Students need to know when they are doing well and when they need help or more practice.

One item that I have had recent success in is an end of lecture notecard on which the students write down the answer to one of the day's activities.



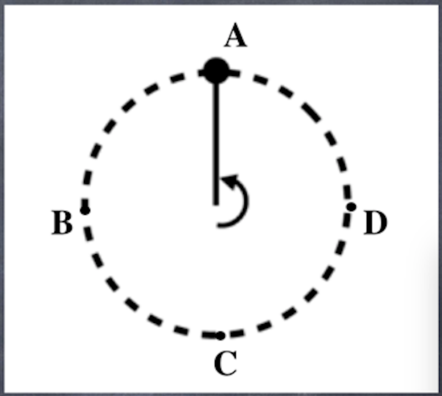
Active Learning

2. Receive feedback from the students on a regular basis (again, ideally multiple times per week).

As I look over these notecards that are created by the student, I get a good look at their deficiencies and see what I need to do in order to improve my teaching.

Clicker Question 3B-2

A ball on the end of a rope is moving in a vertical circle near the surface of the earth. Point A is at the top of the circle; point C is at the bottom. Points B and D are exactly halfway between A and C. At which point do the acceleration, tension force, and gravitational force vectors all point in the same direction?



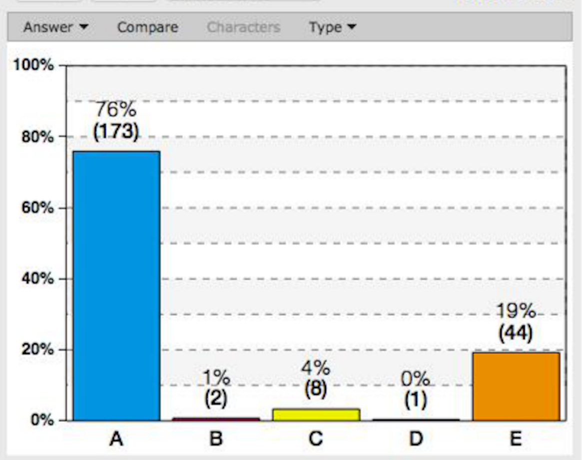
A) Point A.

B) Point B.

C) Point C.

D) Point D.

E) At none of these points will the acceleration, tension force, and gravitational force vectors all point in the same direction.



Specifically targeted misconception on final and found 40% had similar issues.

Addressing Misconceptions

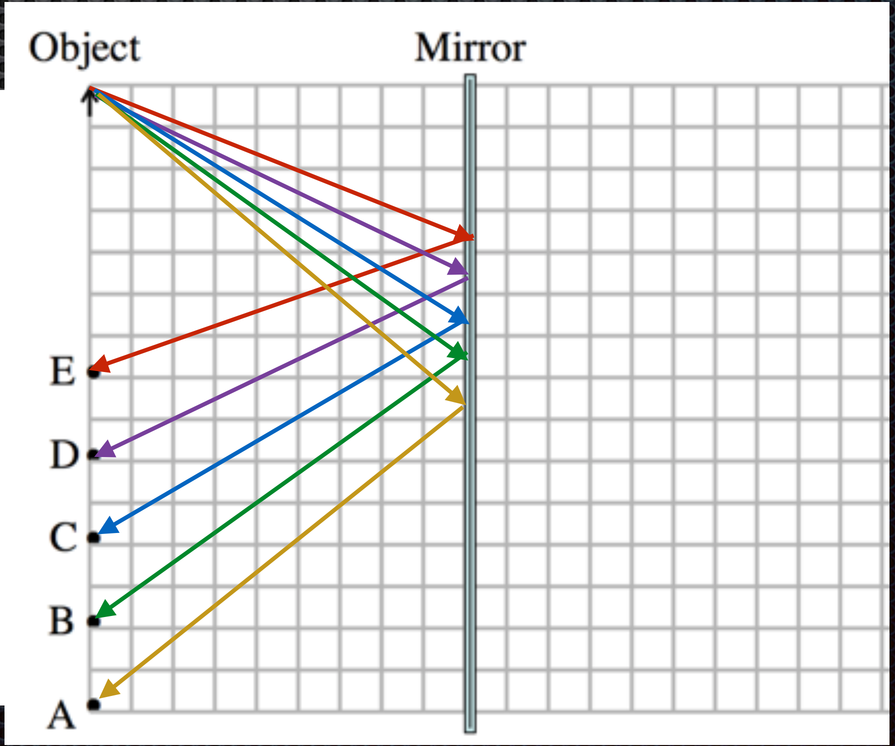
1. If a man wishes to use a plane mirror on a wall to view both his head and his feet as he stands in front of the mirror, the minimum required length of the mirror:

   a. is equal to the height of the man.
   b. is equal to one half the height of the man.
   c. depends only on the distance the man stands from the mirror.
   d. depends on both the height of the man and the distance from the man to the mirror.
   e. is equal to one quarter the height of the man.

- F12 Physics 2C (Engineering/Physical Sciences): 18.6% correct.

1. The figure to the right shows an object to the left of a reflecting mirror and five points A to E (also to the left of the mirror). Consider light rays emanating from the tip of the arrow.
   a. Draw five rays from the object that pass through points A to E (one ray for each point) after reflecting from the mirror. Make use of the grid to do this accurately.

   b. Extend the five reflected rays behind the mirror (*i.e.* extend them as your eye would track back rays reflected from the mirror). At what point do they meet? How is this point related to location of the object?

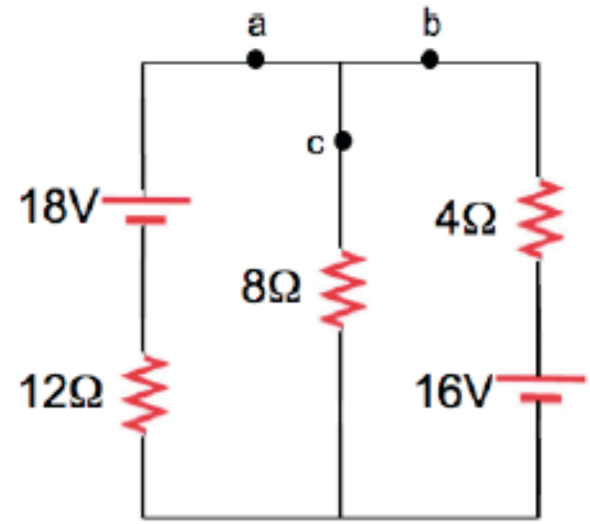


- S15 Physics 1C (Biological Sciences): 40% correct.

Addressing Misconceptions

- F13 Physics 1B (Biological Sciences): 73% correct.

For questions 8 through 10, you are considering the circuit diagram to the right, which is composed of three resistors and two batteries. There are also three points (a, b, and c) in the circuit you that you will be examining (these are just points in the wire and have no circuit elements at those locations). When referring to current in these questions, please note that we are always referring to conventional current. Assume all given values are known to two significant figures.



8. What is the magnitude of the current at point a?

a. 0.50 A.
b. 0.67 A.
c. 1.0 A.
d. 1.5 A.
e. 2.0 A.

- S13 Physics 2B (Engineering/Physical Sciences): 54% correct.
- S12 Physics 2B (Engineering/Physical Sciences): 49% correct.

Active Learning

3. Create an environment that helps students to create their own questions.

4. Inspire students to be well prepared for class.

5. Create learning goals and treat them as your daily road map.

It is imperative that students come to class well-prepared for the material to be covered; which usually means performing pre-reading or other tasks (such as PhETs).

This can be accomplished by simple online reading quizzes of the pre-reading, but can be hammered home by encouraging them to be metacognitive.

Active Learning

Metacognition prompts have helped us to a) prepare students for class and b) synthesize the subject matter after class.

Please respond to one of the writing prompts below. If none of the prompts pique your interest, then you can write about anything related to your learning of this lecture's topics.

Your response should be about 200 words in length; as a reminder, you will be graded on effort. This is due the midnight before the next lecture.

1) Was there any concept that was particularly difficult for you from Lecture 8? State what it was and describe what made it difficult for you to comprehend?

2) Was there anything particularly simple from today's lecture? Discuss what made that topic simple for you.

3) The harmonic oscillator is almost always a good first approximation to a system that displays any kind of oscillations, even if they're not sinusoidal. This is true both in classical and quantum physics. Why do you think this is true? What places the harmonic oscillator in such a unique position?

Active Learning

Student responses:

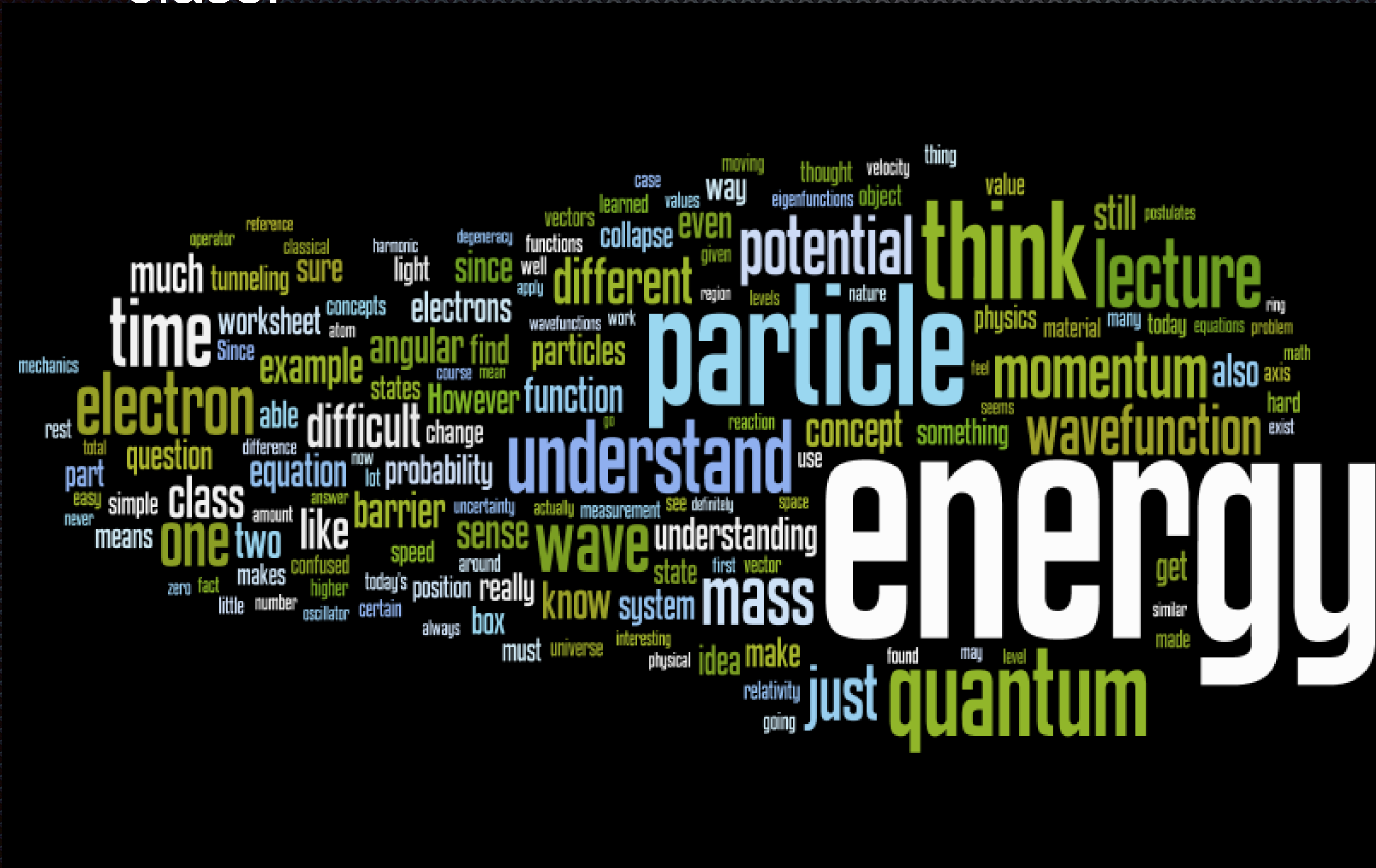
I think the difference between oscillation and probablity densities was a little confusing to me, but was a little bit cleared up in today's lecture. The bigger concept that is hard for me to understand or grasp is how we relate the harmonic oscillator to the probability, because it seems like it implies that the function is oscillating.

I think that the quantum mechanical oscillator is a good first approximation for both classical and quantum systms because it is the gaussian which seems to naturally occur everywhere in our universe. I remember learning is a my probability class and statistics class that over time and with increasing sample size, all distributions will start to look more and more gaussian in form ...

What was the easiest thing to understand today was this potential well created by the V(x) equation. Within this well there is oscillation and within that oscillation are nodes. These nodes are determined by the number n of the wave equation, as n increases, the number of nodes as well. It is directly proportional. So over time the wave function in this potential well looks more and more like a sinusoidal wave as the number n increases. What is very important to note is that when solving for these nodes or vanishing points...

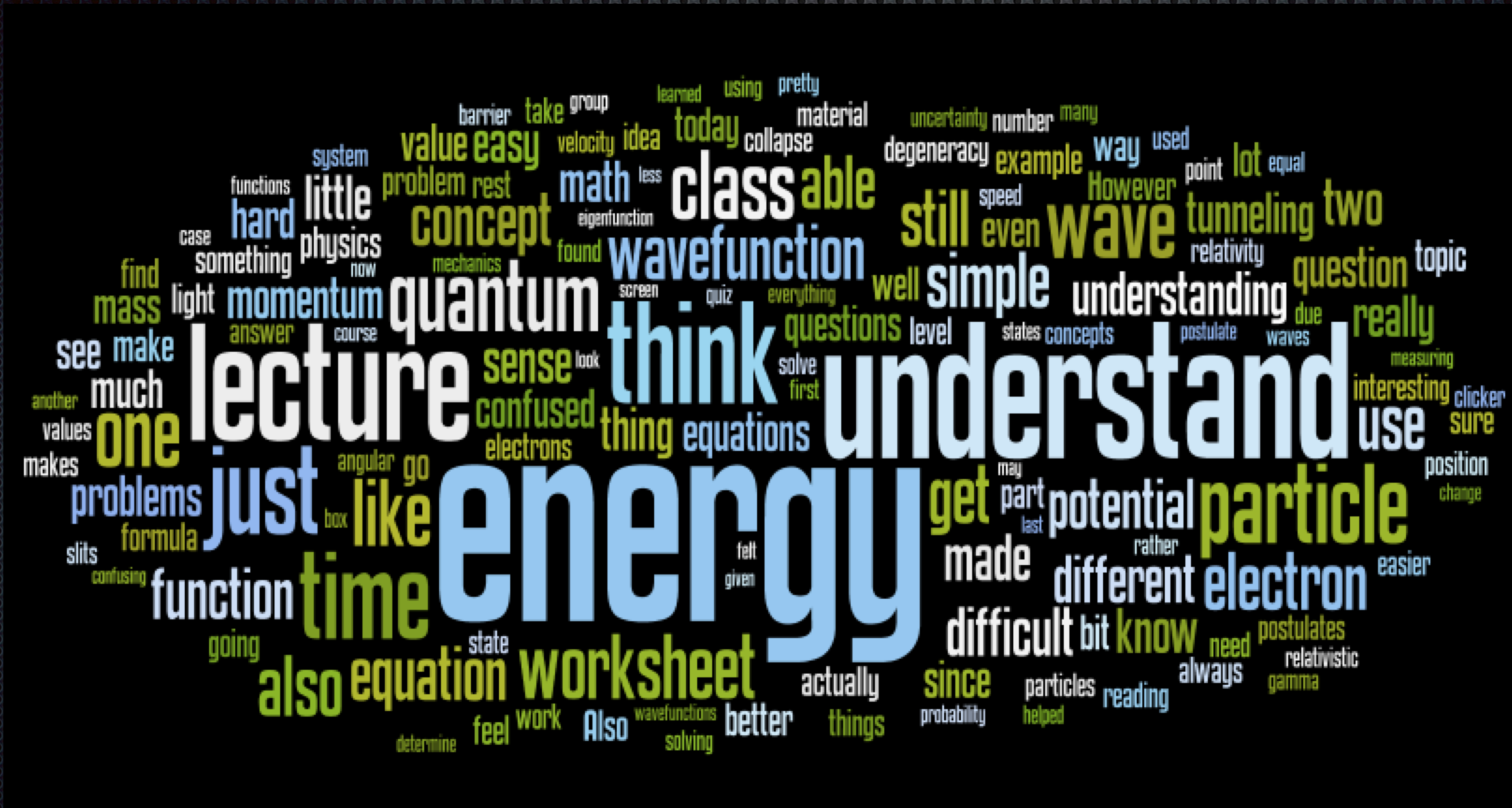
Active Learning

Student word clouds from the top students in the class:



Active Learning

Student word clouds from the bottom students in the class:



Active Learning

6. If it's an important concept or skill, then have the students do it.

Early on in my teaching career that I could teach students how to practice problems and learn concepts by performing complex examples in class.

I would commonly perform a type of example in class and then assign plenty of homework on it.

Projectile Motion, for example, is a subject that I would devote well over 50 minutes trying to explain to them.

I would try to incorporate fun aspects to it.

Diagonal $\vec{v}_i$

"Jeremy Clarkson - Hot Metal"
(Source: ©2 Entertain Video)
http://www.youtube.com/watch?v=OpOhEN_5qiA

Active Learning

Projectile Motion

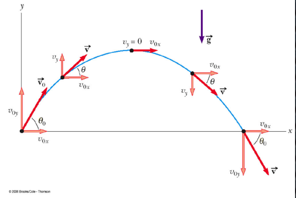
Typical Projectile Motion Problem

A cannonball is shot at a given angle (30.0°) with a certain muzzle velocity (100m/s). How far from the cannon does the cannonball land?

Answer

First, you must define a coordinate system.

Let's choose the upward direction as positive in the y-direction, and the horizontal direction the cannonball travels as the positive x-direction.

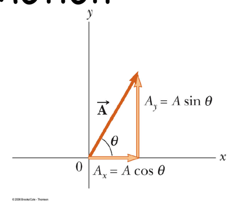


Projectile Motion

Answer

To handle, separate into two problems (x and y).

First, break velocity into components.



$$\sin\theta = \frac{v_y}{|\vec{v}|} \qquad \cos\theta = \frac{v_x}{|\vec{v}|}$$

$$v_y = |\vec{v}|\sin\theta = (100\,m/s)\sin 30° \qquad v_x = |\vec{v}|\cos\theta = (100\,m/s)\cos 30°$$

$$v_y = (100\,m/s)\tfrac{1}{2} = 50.0\,m/s \qquad v_x = (100\,m/s)\tfrac{\sqrt{3}}{2} = 86.6\,m/s$$

Projectile Motion

Answer

Now, use the kinematics equations separately in each direction.

First, let's try the x-direction.

Let's list the quantities we know:

v_{ox} = +86.6m/s

a_x = 0m/s² = constant <-- no acc. horizontally

v_x <-- don't know

Δx <-- finding

t <-- don't know

Let's try the third equation:

$$\Delta x = v_{ox}t + \tfrac{1}{2}a_x t^2 \qquad \Delta x = v_{ox}t$$

Projectile Motion

Answer

That didn't help us much, one equation with two unknowns. $\Delta x = v_{ox}t$

What about the other three kinematics equations for the x-direction (with a_x = 0)?

$$v_x = v_{ox} + a_x t \qquad v_x = v_{ox}$$

$$v_x^2 = v_{ox}^2 + 2a_x\Delta x \qquad v_x^2 = v_{ox}^2$$

$$\Delta x = \tfrac{1}{2}(v_x + v_{ox})t \qquad \Delta x = v_{ox}t$$

We should turn to the y-direction.

Projectile Motion

Answer

Now, let's try the y-direction.

Let's list the quantities we know:

v_{oy} = +50.0m/s

a_y = -9.80m/s² = constant

v_y <-- don't know

Δy = 0 <-- falls to same height

t <-- don't know

What is the one variable we can solve for in the y-direction and place in the x-direction equations?

time, t: so we are now finding time.

Projectile Motion

Answer

Looks like it's the third equation for us.

$$\Delta y = v_{oy}t + \tfrac{1}{2}a_y t^2$$

$$\Delta y = (50.0\,m/s)t + \tfrac{1}{2}(-9.80\,m/s^2)t^2 = (50.0\,m/s)t - (4.90\,m/s^2)t^2$$

$$\Delta y = t\left[(50.0\,m/s) - (4.90\,m/s^2)t\right] = 0$$

$$t = 0 \qquad t = \frac{(50.0\,m/s)}{4.90\,m/s^2} = 10.2\text{ sec}$$

t = 0 represents when the ball was first shot.

t = 10.2 sec is the time is takes to hit the ground.

Projectile Motion

Answer

We input this time into the x-direction equations:

$$\Delta x = v_{ox}t$$

$$\Delta x = v_{ox}t = (86.6\,m/s)(10.2\text{ sec}) = 883\text{ m}$$

This is the horizontal distance travelled by the cannonball.

Other typical questions asked are:

How high does it go?

How long is it in the air?

Then, I would routinely get below 50% on similar quiz questions.

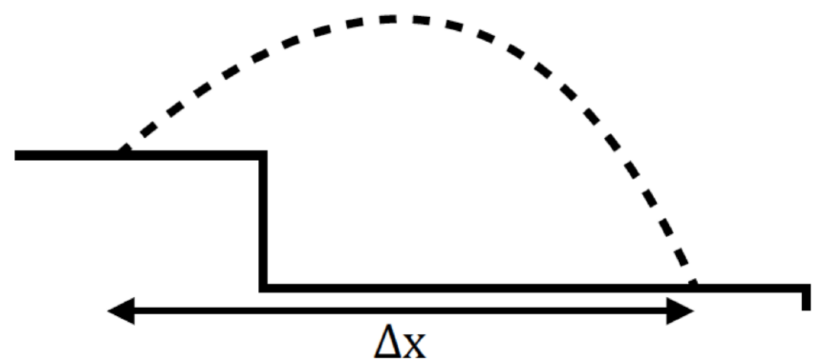
Active Learning

This issue was that they really weren't learning anything as I did the example (no immediate goal to paying attention).

So the time I normally spent doing this example, I turned into time that they spent doing an activity on it (with clickers and notecards).

1. A 2.0 kg projectile is fired with an initial velocity 15 m/s angled 37° above the horizontal. The projectile hits the ground 3.0 m below its initial height as its trajectory is shown in the figure to the right. You may neglect the effects of air resistance.

   a. Define a coordinate system, including the location of the origin and the $+x$- and $+y$-directions.



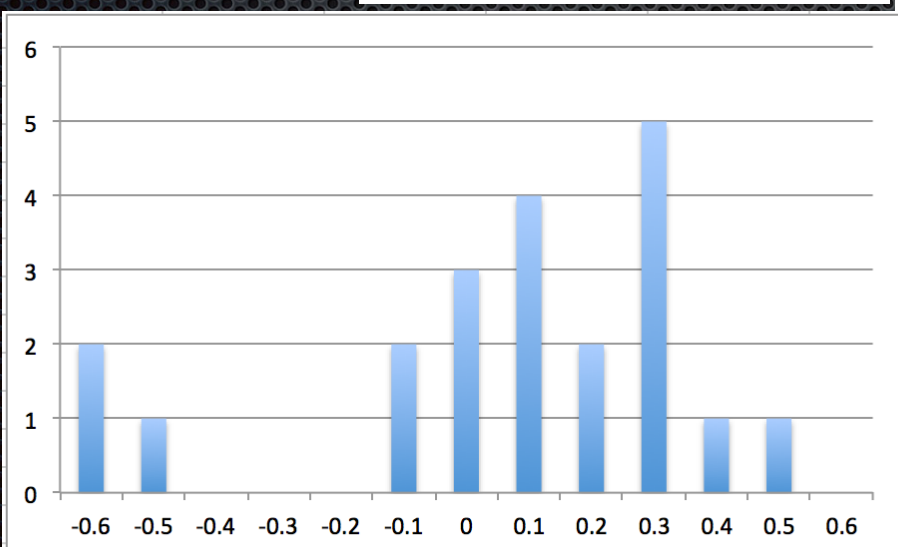
Using the time for activities and then following it up with a notecard raised the students to nearly 70% on a "cannonball" question during the final.

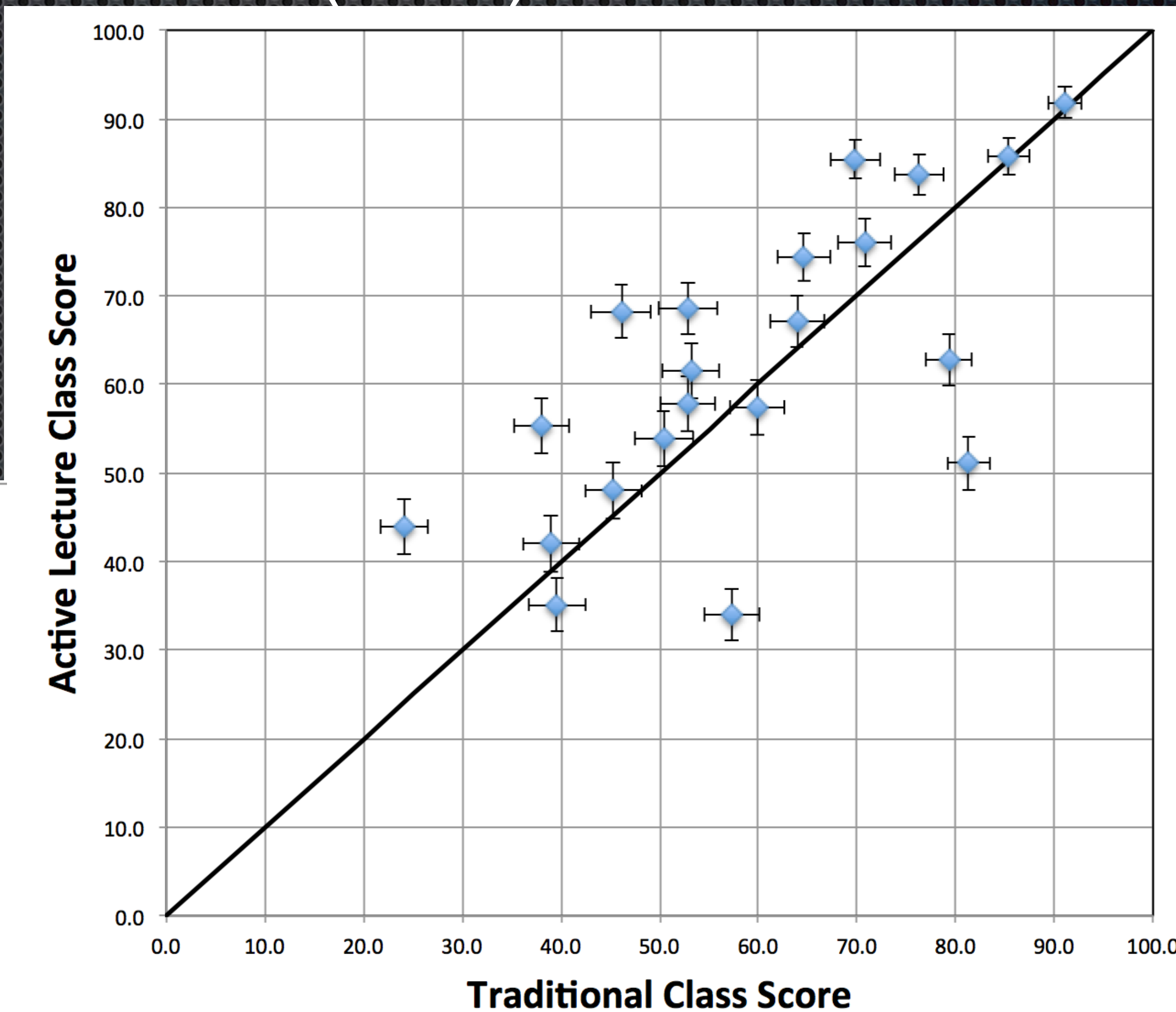
Active Learning

We then went back to look at all of the common mechanics questions between a physics class for biological science majors in a quarter where I wasn't formally following these tenets (W14) and one where I was (S15).

Looking at <g>, which is:

$$\frac{\text{Active - Trad.}}{\text{100 - Trad.}}$$

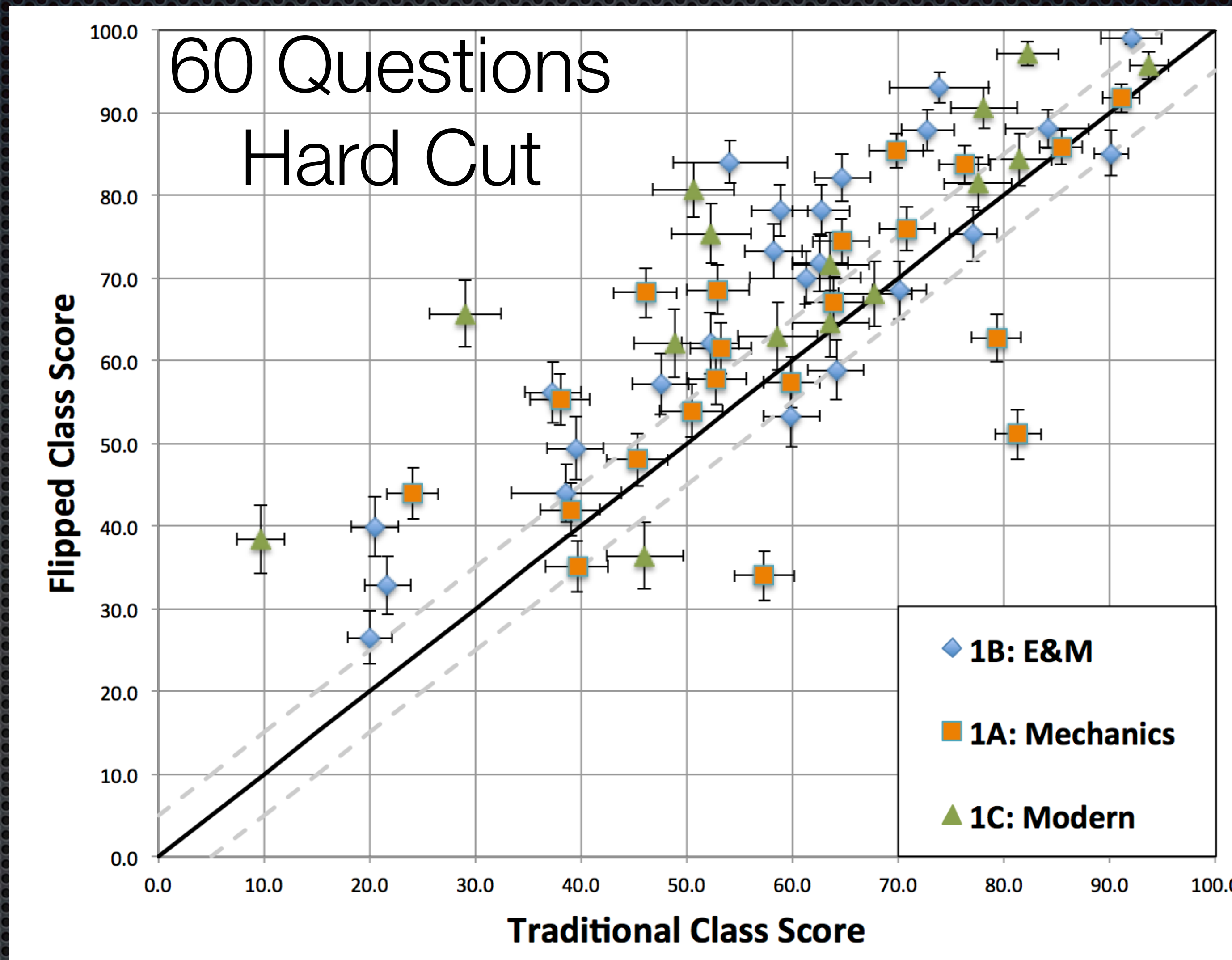




Active Learning

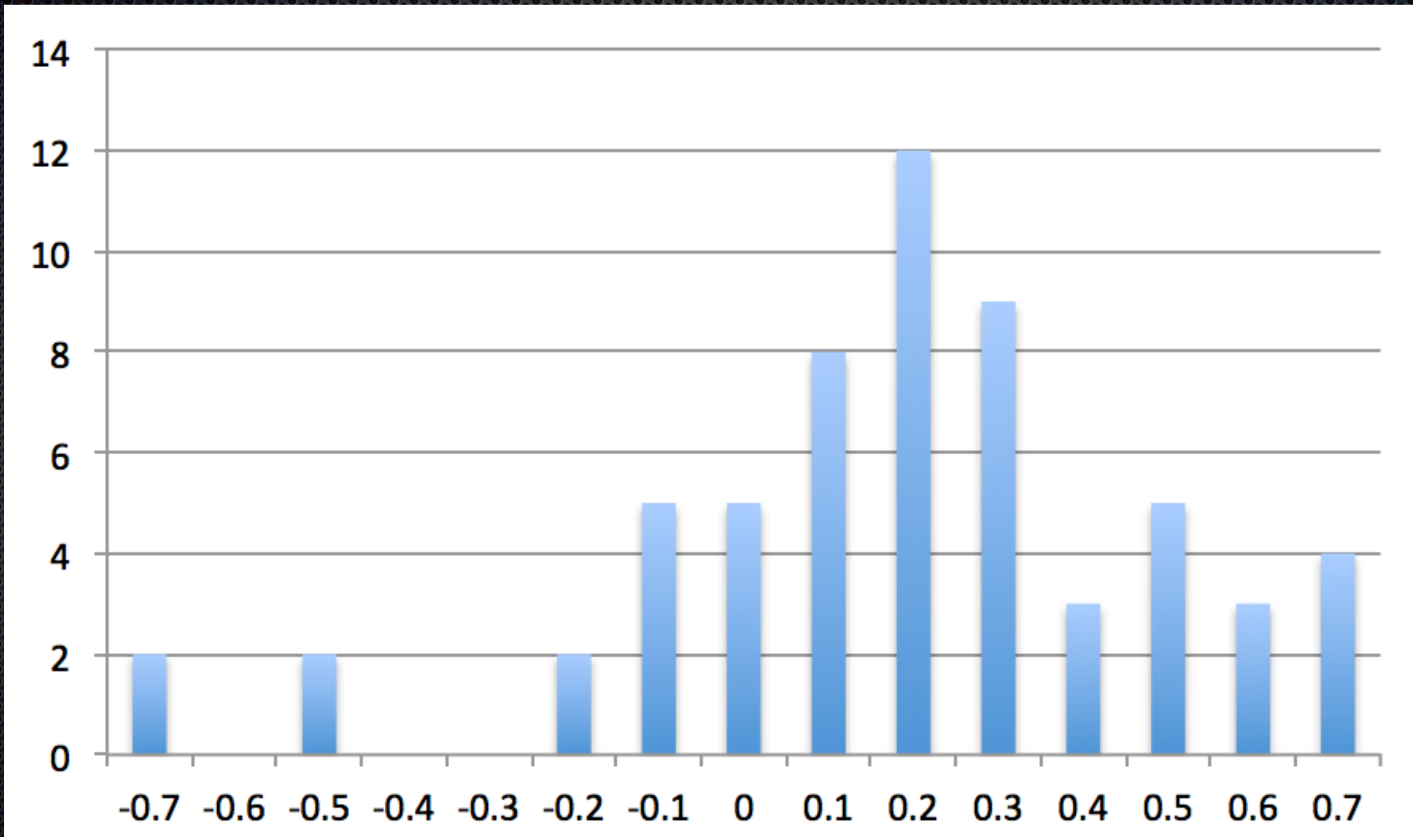
We then performed an exhaustive search over every lower division class that we had taught both flipped and traditionally.

The questions were given a "hard cut" as in they needed to be virtually identical.



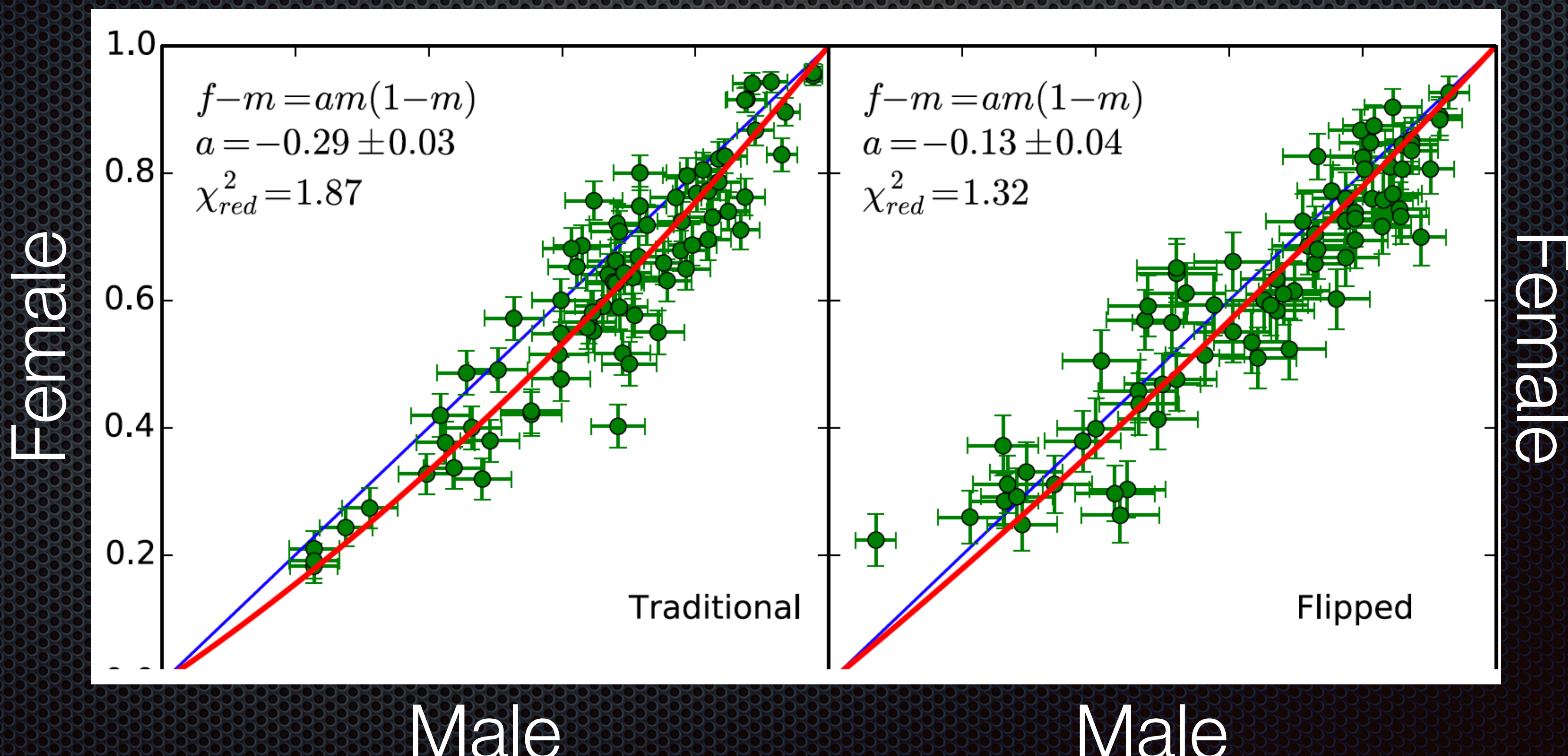
Active Learning

For the same data looking at <g>, which is: $\dfrac{\text{Active - Trad.}}{\text{100 - Trad.}}$



Active Learning

As an unexpected bonus, we found that females would gain on their male counterparts in the flipped environment versus the traditional environment.



Active Learning

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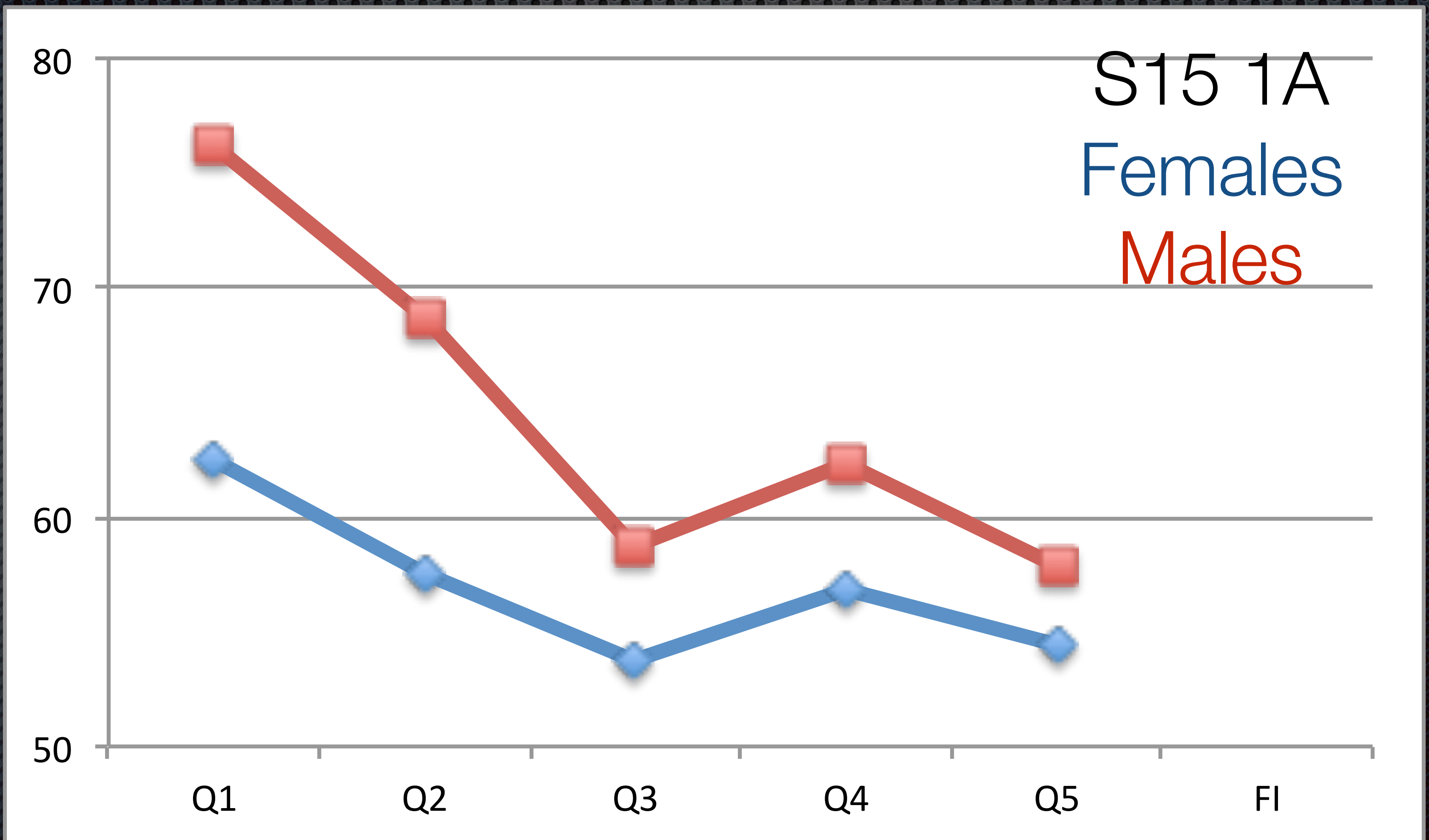


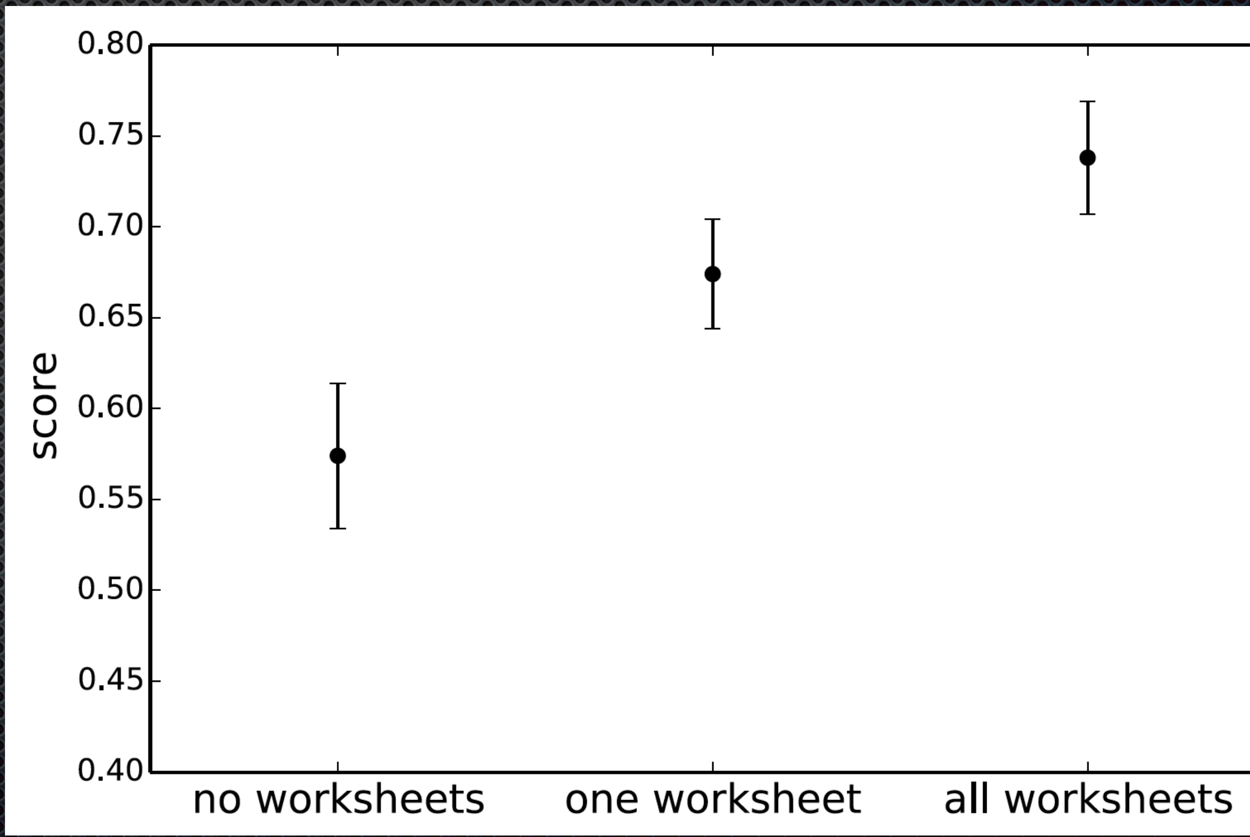
Active Learning

We also examined a particularly tough question: the multi-battery Kirchhoff loop problem.

The data point to the left represents engineering students who went through a traditional lecture.

The data point in the middle represents engineering students who had one worksheet.

The data point to the right represents biological science majors worksheets all quarter.



Active Learning

In my Conceptual Physics class, I went with a video project.

The students chose from a list of topics and created a 4 to 9 minute video to explain the topic.

The students had "checkpoints" throughout the quarter.

Academic Calendar

Monday	Tuesday	Wednesday	Thursday	Friday	
Jan 4 Lec 1A	5	6 Lec 2A	7	8 Lec 3A	
11 Lec 4A	12	13 Lec 5A	14	15 Lec 6A	
18 Holiday MLK Jr. Day	19	20 Lec 7A	21	22 Quiz #1 Groups Due	Note that Monday, 1/18 (MLK Jr. Day) is an academic holiday.
25 Lec 15A	26	27 Lec 16A	28	29 Lec 19A	Note that Friday, 1/22, the Group Announcements are due.
Feb 1 Lec 20A	2	3 Lec 22A	4	5 Quiz #2 Proposals Due	Note that Friday, 2/5, the Group Proposals are due.
8 Lec 23A	9	10 Lec 24A	11	12 Lec 25A	
15 Holiday Presid. Day	16	17 Lec 26A	18	19 Quiz #3	Note that Monday, 2/15 (President's Day) is an academic holiday.
22 Lec 28A	23	24 Lec 29A	25	26 Lec 30A	
Mar 1 Lec 31A	2	3 Lec 33A	4	5 Quiz #4 Projects Due	Note that Friday, 3/5, the Video Projects are due.
8 Video Presentation Day 1	9	10 Video Presentation Day 2	11	12 Class Review	
15	16	17	18	19 Final Exam	Note that the final exam is on Friday, March 19th from 11:30am to 2:30 pm.

The highest and lowest points of displacement are called the crest and troughs in transverse waves, or points of compression and rarefaction in longitudinal waves.

Our System

For every topic:

1. What are your student learning goals for the topic?
2. What are the set of logical steps a student needs to make to gain understanding in each of your learning goals? This would typically comprise the major points in your lecture.
3. What mathematical tools are needed to accomplish your learning goals and what do students need to do to improve their skills in using these mathematical tools? This would typically comprise examples done in lecture.
4. All of this requires prioritization of goals and a significant reduction in lecture time.

Our System

To implement this goal:

1. Students need to come prepared to perform and positively contribute to group work.
2. Students should be encouraged to formulate specific questions before lecture (metacognition).
3. Formative assessment and feedback is needed multiple times per lecture period.
4. Students should produce daily work product for the instructor to browse in order to plan activities to rectify lingering misconceptions. We accomplish this by passing out note cards on which students answer instructor-provided questions.
5. Exams must reflect the content of the group work.

Acknowledgements

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