dy/dan

less helpful

Archive for the 'loa' Category

[LOA] How Technology Can Help

Posted in loa, tech enthusiasm on August 23rd, 2012 7 Comments »

In March, I gave a talk to some math textbook authors describing five strategies for designing curricula for digital media like tablets and computers. One of those five strategies relatedly directly to the ladder of abstraction and my tentative hypothesis that *paper is a problem*, that the constraints and cost of paper lead us to decisions that ultimately make the process of abstraction *very* difficult for students to understand. (ie. Print-based curricula in your teens leads you to tell people that "Math always seemed abstract to me" in your thirties.)

My preference would be that you'd watch the 8.5 minutes from 19:14 to 27:57 of this video. Some of the examples don't work well here in text, but I'm going to lay out the slides and narration anyway so we have a place to argue about this segment in specific.

This gets really fun here. This is a part I'm really enthusiastic about right now. Have students climb the entire ladder of abstraction.

This is NCTM on technology and I think they got it exactly half right. The technology helps us work at higher levels of abstraction but technology also helps us work at *lower* levels of abstraction. Right now, the tasks we give students are focused on this narrow band, this narrow set of rungs in the middle of that ladder and no higher and no lower.

1. Identifying variables in the situation and selecting those that represent essential features.
2. Formulating a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables.
3. Analyzing and performing operations on these relationships to draw conclusions.
4. Interpreting the results of the mathematics in terms of the original situation.
5. Validating the conclusions by comparing them with the situation, and then either improving the model or, if it is acceptable.

Common Core State Standards

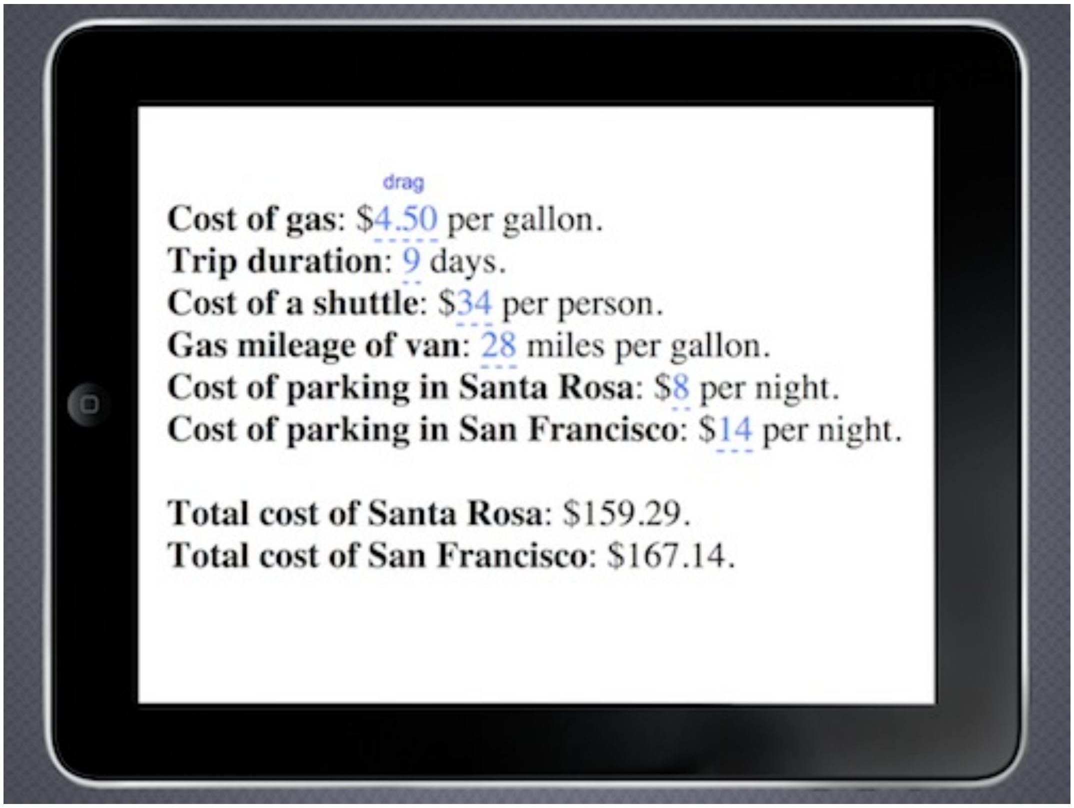
You look at the modeling standard and look at what it says. (This terrifies me by the way.) "Identifying variables. Formulating a model. Analyzing and performing operations. Interpreting the results. Validating the conclusions." That's your ladder of abstraction there. [I won't exactly sign on off that now, FWIW, but let's see where he's going with this. -**dm**] And what do we have students doing? Just that middle rung.

1. Identifying variables in the situation and selecting those that represent essential features.
2. Formulating a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables.
3. Analyzing and performing operations on these relationships to draw conclusions.
4. Interpreting the results of the mathematics in terms of the original situation.
5. Validating the conclusions by comparing them with the situation, and then either improving the model or, if it is acceptable.

Common Core State Standards

They select the operation and apply it. That's it.

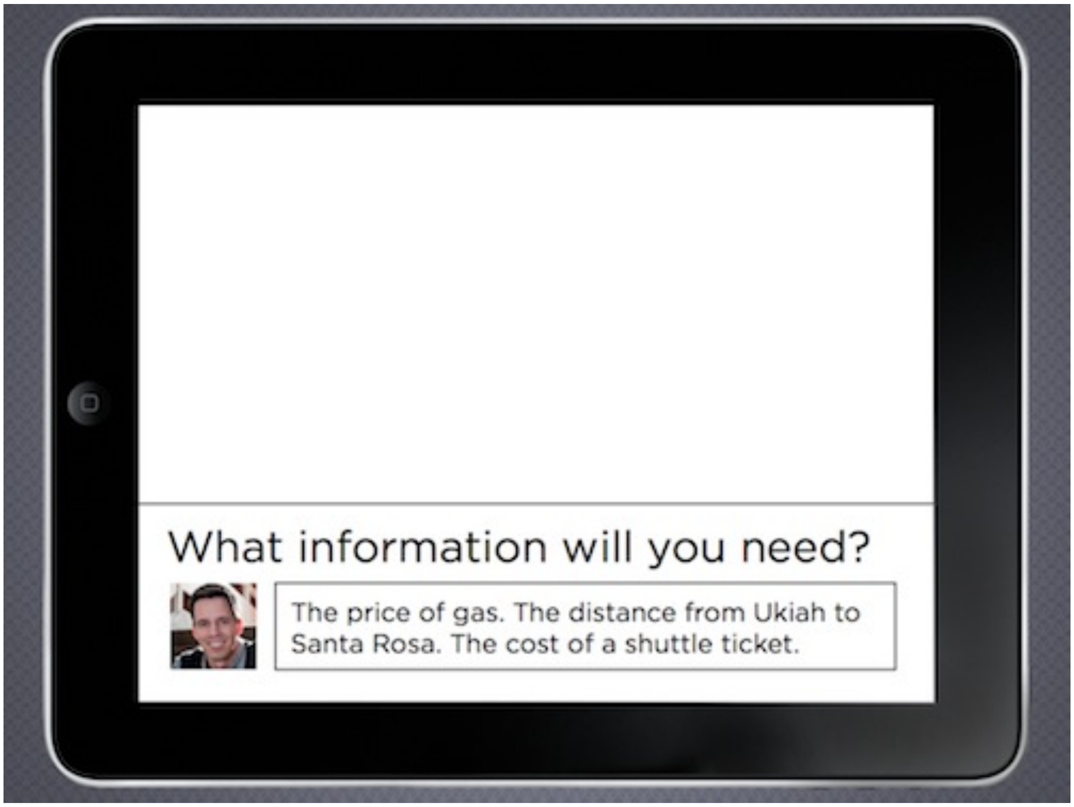
And so this is a tool that was built by a guy named Bret Victor. This is a guy you should get to know. I watched a talk he gave on the plane over here from San Francisco and I had like a physical reaction to this talk it was that good. He has a project called Kill Math, which should be provocative enough for all of you guys to click on the link. He's a technologist, a creator, an artist, an engineer. This is a guy who will provoke your thinking in a number of different ways.



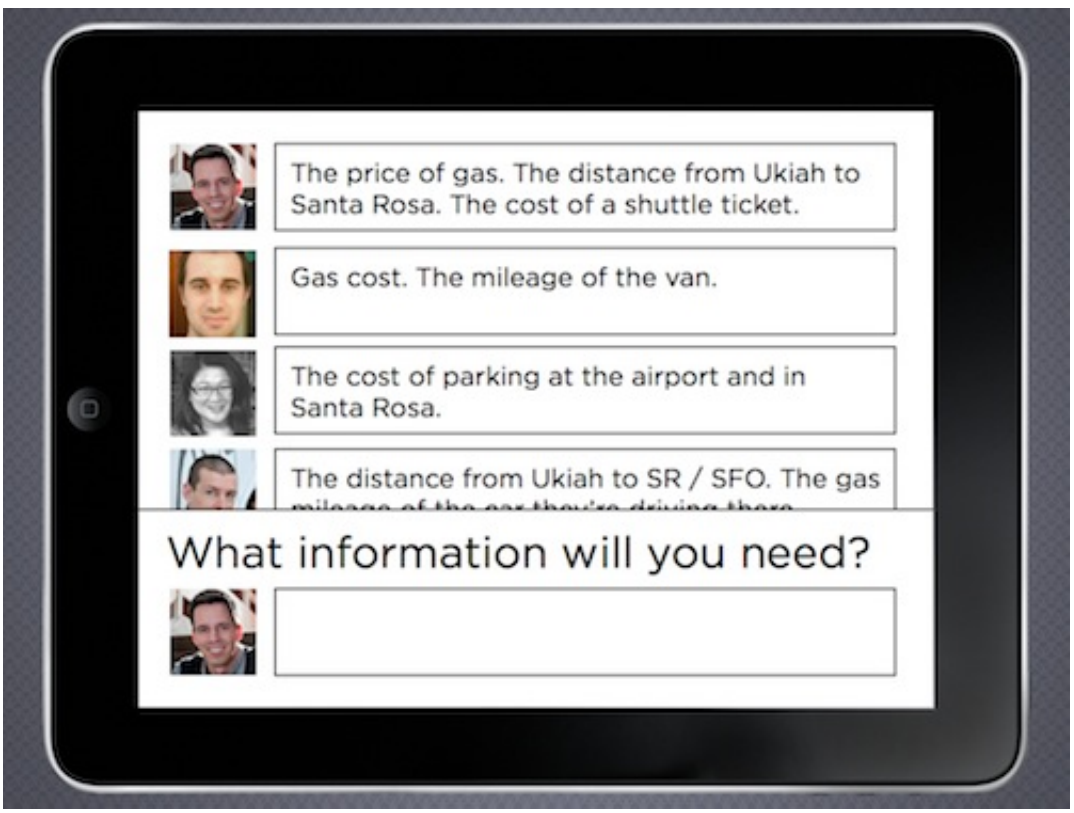
But he created this tool he calls Tangle and I adapted it for use in this problem. And what it lets me do is essentially turn all those parameters into variables and so now once I've solved the first problem, I can slide around on all those things and see what would happen if gas dropped in price or if the shuttle costs went up or if the cost of parking in Santa Rosa dropped to zero. And ask a whole host of new, different, complicated questions. And pose scenarios that are higher up on the ladder of abstraction.

But we also need to have students work at *lower* levels. Like, where did those parameters come from? You and me. We brainstormed them [earlier in the session **-dm**]. But in the textbook those are given to them. The text tells students what parameters they're going to need and it gives them that information.

Thats a valuable lower rung on the ladder that students need experience with. Once we have the task posed, let's just ask that student, "What information will you need here?" And just let the student think about it for a second, and then type a few things down in a low-risk environment.



And maybe let the student see all the classmates' responses also, the results of that brainstorming.



That's a lower level of abstraction. You and I are constantly dealing with the question, "What information do I need to solve this task?" That's a question that gets very little air time in our print-based curricula.

Again, we have a third page for this problem now. We have the starter — the context, the visual. We have this rung — this level of abstraction. And then the rest of the problem. That's three pages for this task right now. You can't do it in print.

We could compress all of those. But you can't put a kid on a higher rung and then ask them to work on a lower one. Like I can't give the kid all the information they'll need and then ask them "what information will you need?" The horse is out of the barn. So we have to split this up over multiple "pages".

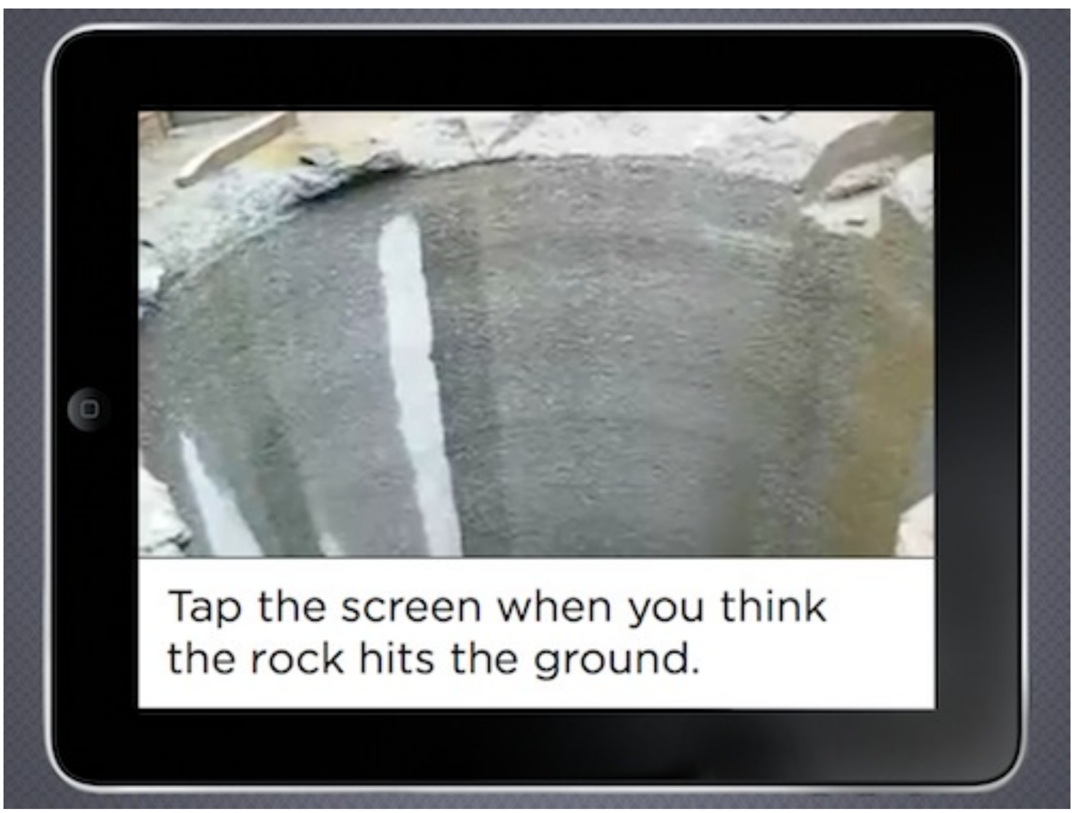
Go even lower. This is, I think, the lowest rung on the ladder of abstraction.

We show. We don't tell. And then we pose the task immediately, "Does the ball go in?" And, at this point, how are you not speculating? Like how are you not guessing. I know you have a theory. You've got an idea in your head whether it's going in or not. Can I get you guys to raise a hand if you think it's going in? Okay. And the rest think it's going out. I'll just assume that. That is a valuable moment of intuitive and guesswork and it's engaging for students so let's give them an outlet for that on the page there.

Just let them tap a yes or a no. "What do you think?" And then we'll aggregate all those responses.

This has cost us nothing in terms of cash or weight on the student's back. It's cost us a brief second of class time, which makes whatever meager return we get on this investment just incredible. Just in terms of, "Well now I want to know the answer." We've got that student.

And that's everywhere, in applied math particularly. "How many minutes will it take to fill?" Every student puts down a guess before we get in the real meat of it.



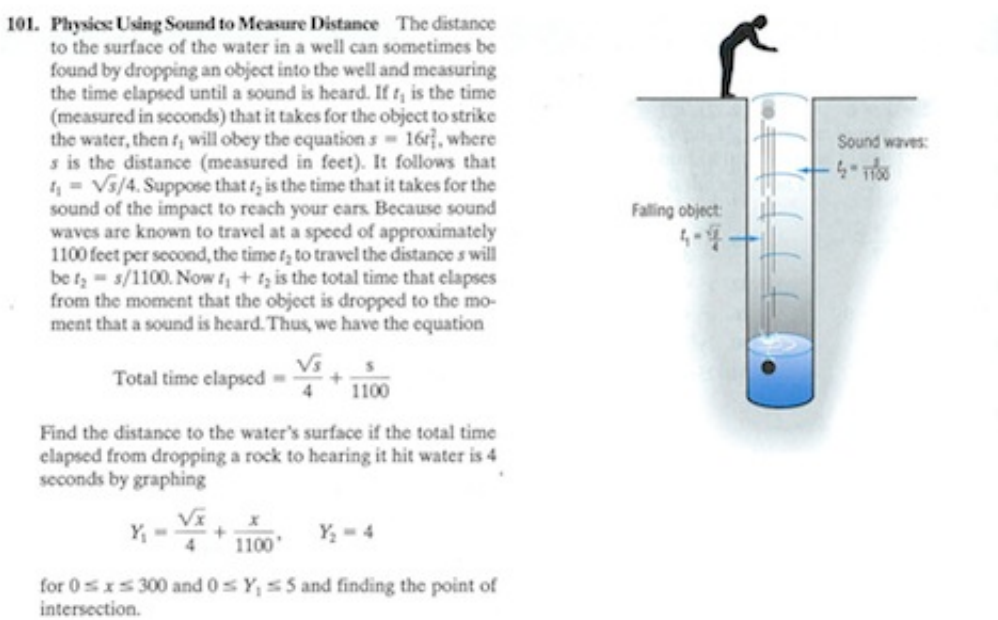
This is going to get really fun here. Obviously I will ask you, "How deep do you think it is?" That will happen. But even better is this. I'm going to ask you to tap on the screen when you think the rock hits the ground. And I can't have you do that. [This part makes no sense on paper but it's pretty awesome in the video **-dm**] But I'm going to ask you to raise your hand when you think the rock hits the ground.

Now tapping obviously has a lot of advantages over raising your hand. It's more surreptitious. You have your own answer. You're less biased by others. I like that about it. But for now you saw that video before. I'm going to ask you to raise your hand up when you think the rock hits the ground.

[Most people raise their hand on the huge boom. I raise my hand way earlier than the boom. -**dm**]

We were all over the place there. There was some large clumps there at the end. I think the you guys were late. I don't know what the answer is, exactly, but I know that this crowd here, on that big boom, was late. Why? What was the question that these people answered perfectly? "When did I hear it?" Which is different than "When did it hit the ground?" Right. Because the sound is coming back up.

And you guys should see your faces right now. Some of you guys are kind of like, "Huhhh." So using a very low rung — which student couldn't answer that question? — we've highlighted that there's more here than projectile motion. There's also the speed of sound going on. We've got that in your head.



101. Physics: Using Sound to Measure Distance The distance to the surface of the water in a well can sometimes be found by dropping an object into the well and measuring the time elapsed until a sound is heard. If t_1 is the time (measured in seconds) that it takes for the object to strike the water, then t_1 will obey the equation $s = 16t_1^2$, where s is the distance (measured in feet). It follows that $t_1 = \sqrt{s}/4$. Suppose that t_2 is the time that it takes for the sound of the impact to reach your ears. Because sound waves are known to travel at a speed of approximately 1100 feet per second, the time t_2 to travel the distance s will be $t_2 = s/1100$. Now $t_1 + t_2$ is the total time that elapses from the moment that the object is dropped to the moment that a sound is heard. Thus, we have the equation

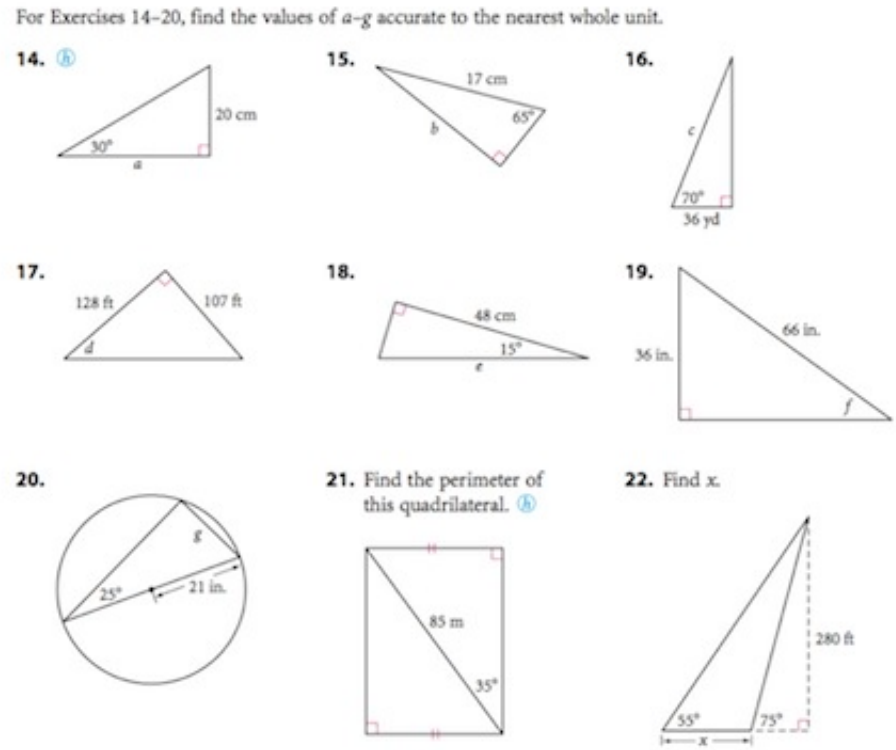
$$\text{Total time elapsed} = \frac{\sqrt{s}}{4} + \frac{s}{1100}$$

Find the distance to the water's surface if the total time elapsed from dropping a rock to hearing it hit water is 4 seconds by graphing

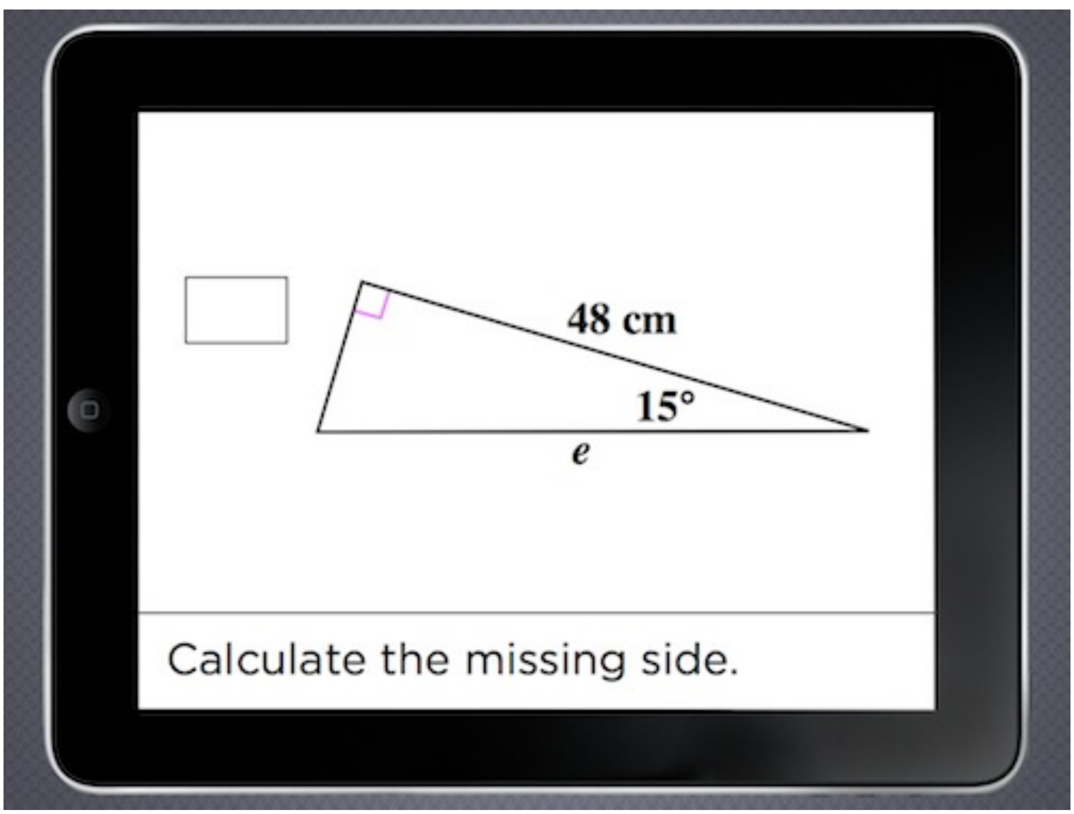
$$Y_1 = \frac{\sqrt{x}}{4} + \frac{x}{1100}, \quad Y_2 = 4$$

for $0 \le x \le 300$ and $0 \le Y_1 \le 5$ and finding the point of intersection.

And thinking about how that happens in print, we get a very different reaction off this right here when we're just writing and writing and writing about the speed of sound. It's different.

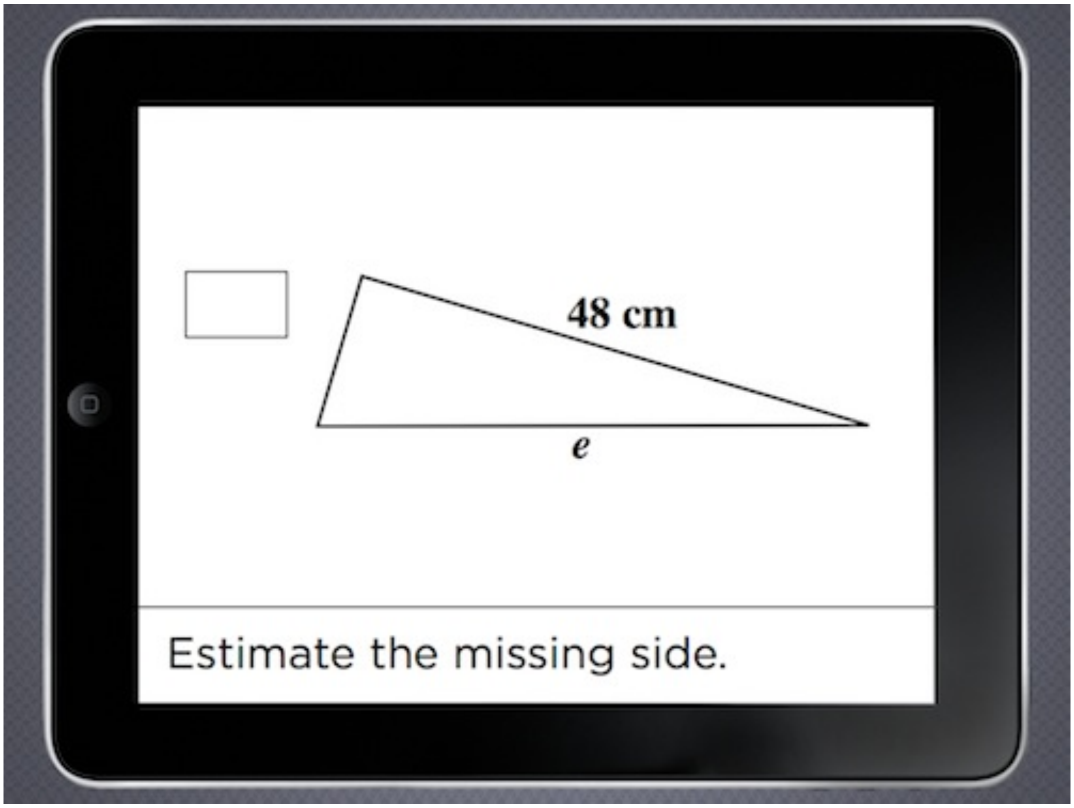


This plays out in pure math in some fun ways. This is your very traditional trigonometry practice unit. We jump into problems like this right here.

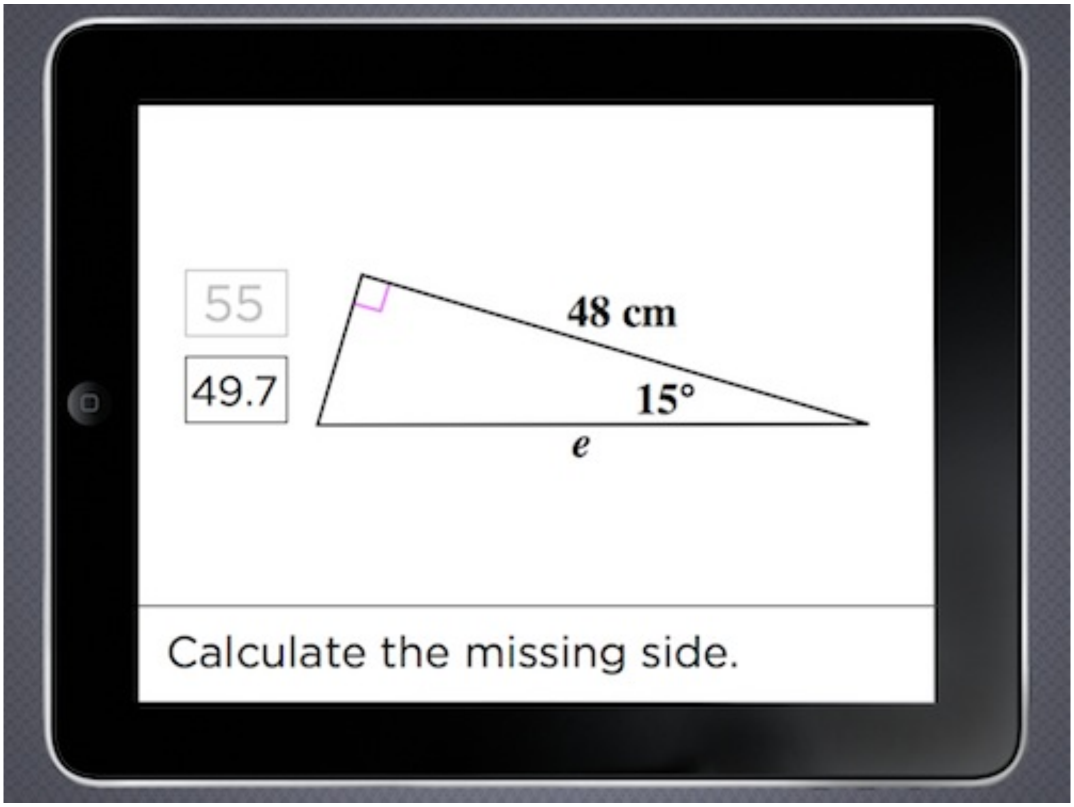


Calculate the missing side. And we do this very interesting thing on these problems where the student gets an answer and we go around and we look at the answers. When the answer is wrong, we ask, "Does your answer make sense? Is your answer reasonable?" It has the effect of stigmatizing that question, of course, so they know "Is your answer reasonable?" means "Your answer is wrong." But it's interesting when we ask that question. We ask that question once they've climbed to the very highest rung on the ladder. They've selected a model. They've performed the operation. They are way high up there. And we ask them to climb on down and access the lowest rung on the ladder. "Is your answer guessable, reasonable? Does your intuition say, 'Yeah, it works.'"

I don't have a ton of evidence but I think that's hard for students. Far better would be to start the student at that low rung and then build up. So I'm talking about this right here:



We just ask them to estimate it at the very start. All the same problems. They're just going to see them twice, though. They're going to go through the first time in a couple of minutes and just put down their best guess at how long that side will be. So maybe the student says, "55, maybe," and moves onto the next one. It takes two minutes.



Then the next time through, we give them this angle here. Their answer — their intuitive answer — is still up there so that when the student gets that it'll be 49.7. Like, yeah, that's kind of within the ballpark there. And we don't have to answer the question, "Is that reasonable?" Their reason is staring them in the face already.

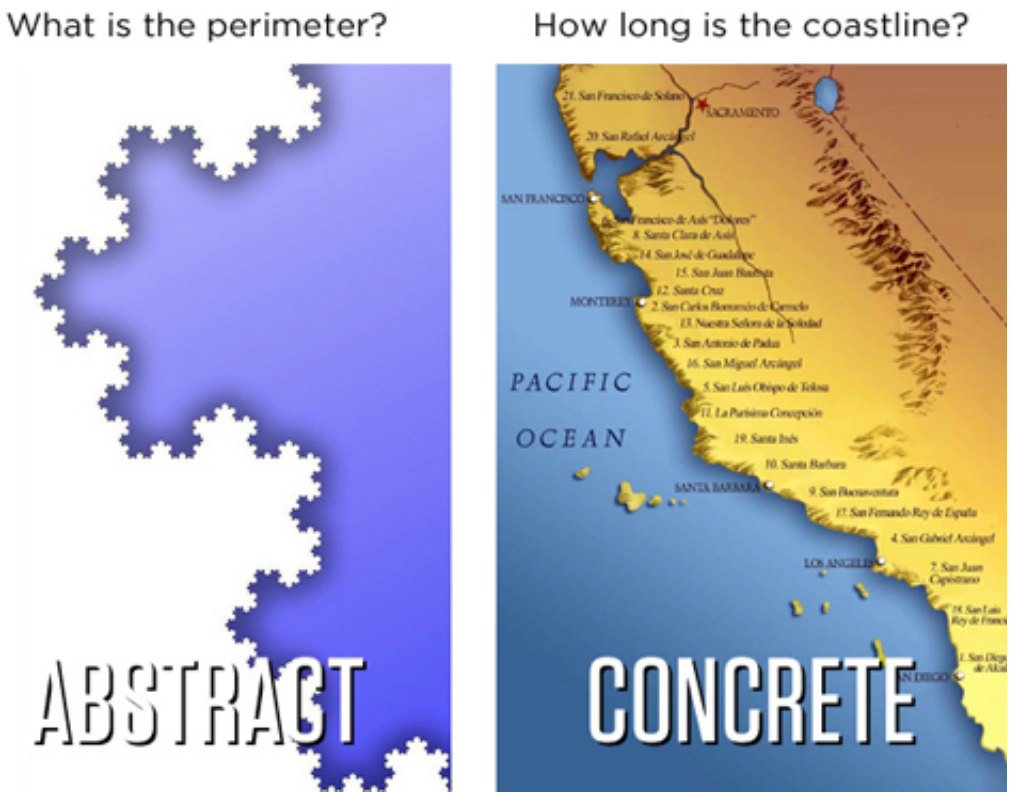
So if they were to use the wrong identity. It would be more obvious. So if the student got 14, or whatever it would be, if they had solved accidentally for the other side, it might be more obvious seeing that guess staring them in the face.

I'm enthusiastic about that.

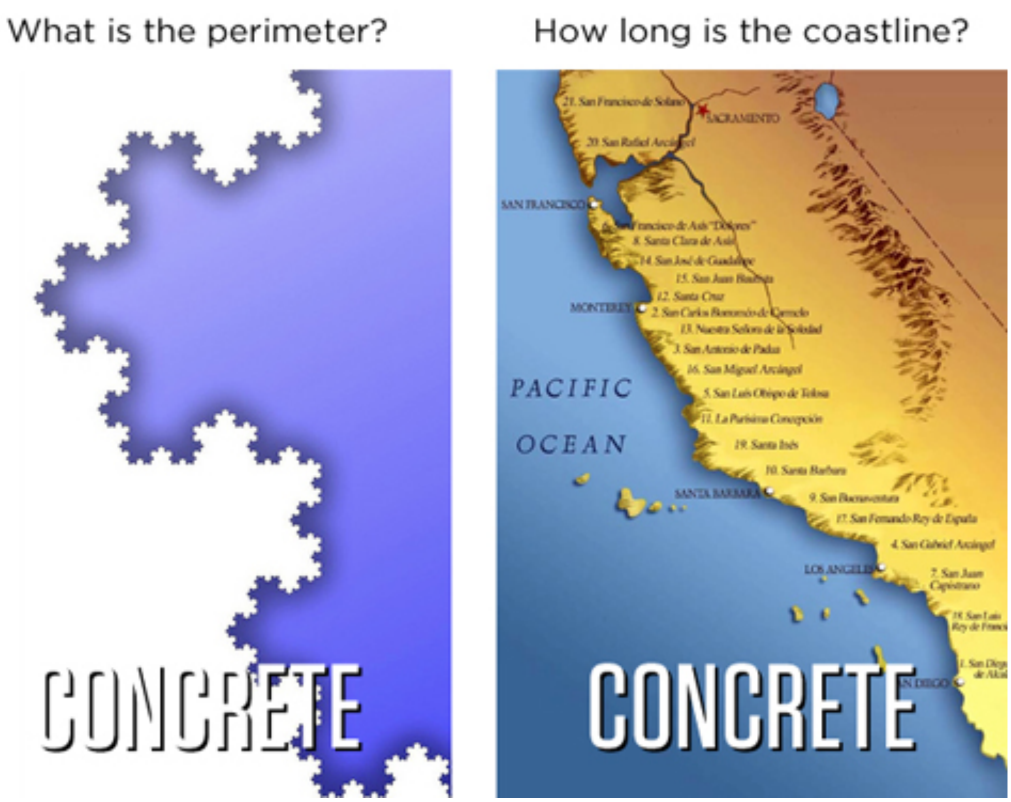
[LOA] Misconceptions

Posted in loa on August 7th, 2012 14 Comments »

Bryan Meyer claims to prefer the abstract task on the left to the concrete task on the right:

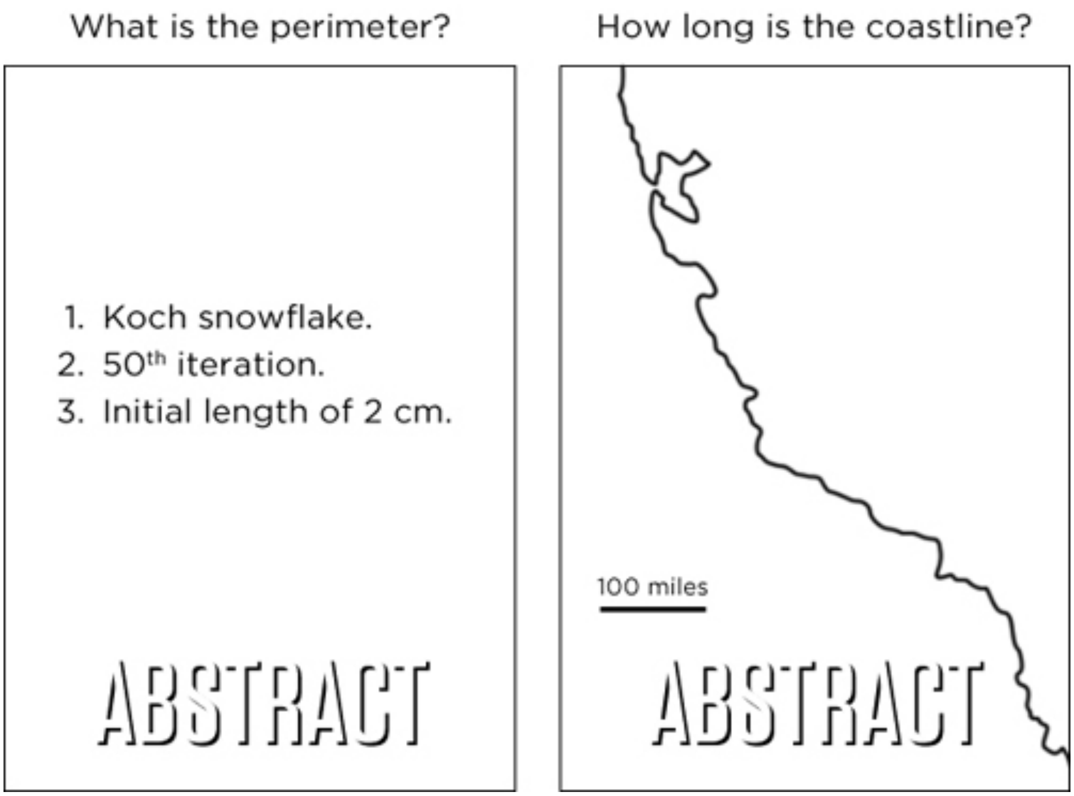


But both of those images have information that is extraneous to the question Bryan poses about them. Color information is irrelevant in both, for instance, so you get rid of it. You don't need the names of California's missions or the name of the ocean to its west. Both images are in need of abstraction. Therefore they are both concrete.



Or at least they're more concrete than what we get after we ask ourselves:

1. What information is important?
2. How do I represent it?



This points to the highly subjective nature of the *adjectives* "abstract" and "concrete." They're often statements of preference (eg. "I prefer concrete to abstract" or vice versa) and they're both relative terms. Everything is more abstract and more concrete than something else on the same ladder. But we're looking at two different ladders here, not one.

[LOA] A Japanese Classroom

Posted in loa on August 2nd, 2012 38 Comments »

So here is a task that occupies maybe two rungs on the ladder of abstraction:

> You bought some 40-cent pencils and some 70-cent pens. There were 10 of them in total for 460 cents. How many pencils and ballpoint pens did you buy?

At this altitude, it's difficult to apply your intuition to a solution. The important information has already been identified. You'll decide how to represent that information (symbolically, perhaps, with variables and two simultaneous linear equations) and what to do with that representation (manipulate those equations, solving for both unknown variables). But that's the extent of the task ladder.

So watch and marvel, as I have, at video of a skilled Japanese teacher reconstructing that task ladder to include more rungs above and below what few currently exist. I have watched it five-or-so times since Steve Leinwand introduced it in his April talk at NCTM. I encourage you to do the same. For the sake of our conversation here, though, I have created a smaller excerpt of just the teacher's *questions*:

Here are those questions and some commentary. The questions are listed in chronological order, like a script, but I'm sure you understand we're starting at the bottom of the ladder:

1. This is what we're going to study today. What is this?
2. What's this?
3. How much are they? Guess.
4. So how much is a ballpoint pen?

I prefer tasks that make more intentional use of guesses, prediction, and intuition. But I don't know what else he could do with this task except ask his students if they know what a ballpoint pen is and check to see if they have enough sense of that context to guess at its cost.

5. You bought some 40 yen pencils and some 70 yen ballpoint pens. There were 10 of them in total for 460 yen. How many pencils and ballpoint pens did you buy?

The task is introduced.

6. A table?
7. Do you think the table would help you?
8. Do you understand what the table is?
9. Rio, do you think the table would be useful?
10. Well then, if we're going to make a table, we need some labels, don't we?
11. What kind of table?
12. Do we need a label like this?
13. Do you understand this?
14. What else do we need as a label?
15. Do we still need something else?
16. How about this? "The total price."
17. What do you mean 0-10?

18. You mean no pencils?
19. And how many ballpoint pens?

This is one of my favorite moves in the lesson. A similar task in the United States might explicitly direct students to create a table. It might *provide* a table with several rows pre-filled. In both cases, *the problem would be abstracting itself*. It would be answering the question, "How do I represent the information that's important?" *for* the student. It would be locking the process of abstraction inside a black box, far from the student's view. And then twenty years later we'll marvel when that student, now grown, complains that "algebra always seemed too abstract."

But the Japanese teacher isn't sending his students off to *discover* the abstraction. Yes, the *students* are making most of the crucial choices here — from the selection of a table to the labels of the table to the domain of the table — but the teacher steps in after each of those choices and makes them totally explicit.

The choice to include "0 pencils" in the domain of the table, for one example, is far from obvious. So when a student suggests it, the teacher underscores that suggestion *over and over again*, doing everything but sending a skywriter up in the air to write "YOU MEAN *NO* PENCILS?!" above the school in smoke.

20. Well there are many combinations of the numbers right?
21. Seika, can you tell me any examples of the combination?
22. 3 pencils and 7 pens. Did you make the same combination?
23. Is it correct?
24. Are there any mistakes on the board, please tell me?
25. But before we see that, there already is an answer, isn't there?
26. What is the answer?
27. This pair?
28. Is it similar with your notebook?

The teacher asks his students to calculate the table by hand. In another bright move, he passes out the table's 11 columns to different students who calculate and return them. Now those columns are pinned to the board, arranged in no particular order.

He notes that they have solved the problem. One of the columns contains 460 yen. That's the combination of pens and pencils they're after. The task seems complete.

But the ladder continues upward.

29. Can someone arrange the cards and make the table easier to see?
30. Why did you arrange the cards like this?
31. But why?
32. It's easier to see?
33. The order of numbers?
34. For example, if I change the cards like this, is it wrong?
35. This is the answer, is that all?

He's still picking at the abstraction!

Two girls come up and arrange all those haphazard columns into ascending order in a table. And he asks them, "Why did you arrange the cards like this?" He doesn't let up. He takes one column and sets it out of order. "Is it wrong?"

No, it's just less useful. A student says, "It's easier to see."

What's easier to see?

The student explains that when we arrange the table in order, the change in total price is hard to miss. When they're out of order that change is hard to see.

36. How does our method match the Easy / Fast / Accurate rule?
37. Is it fast?
38. It is easy?
39. Is it accurate?
40. How can we solve the problem more quickly?

Now we're abstracting over new variables: speed, ease, and accuracy. The students decide unanimously that their method is accurate. They're mixed on ease and no one thinks it's fast. So now we're ready for a faster, easier method for a new problem.

41. You bought some 60 yen colored pencils and some 80 yen markers. There were 12 of them all together. The price they cost was 820 yen. How many colored pencils and markers did you buy?
42. What is the title of today's lesson?

What amazing work from such meager beginnings.

A few final notes before we dive into your commentary:

- **Titles.** What's with titling the lesson at the end of the day? Anyone know what's going on there?
- **Technology.** Blackboard. Chalk. Teacher voice. Student voice. Paper. Pencil. It's multimedia in the most literal sense of the word. (Tentative hypothesis: it's very difficult to work on the ladder of abstraction if your tasks are limited to one medium.)
- **Tables.** A table is a representation of a context's most important information. It's an element of an abstraction with which math teachers are *extremely* comfortable. I think we find it easy to assume, particularly at the secondary level, that what's obvious to us about these representations is also obvious to our students. I love how every single aspect of the table in the video is up for negotiation and debate — its labels, the inclusion of zero values, the fact that you probably oughtta put *something* in ascending order. *Nothing* is taken for granted.
- **Time.** At the end of class, the teacher notes that, wow, that took a lot of time. It turns out a deep understanding of abstraction doesn't come for free.

BTW: Michael Pershan offers [an excellent analysis of Khan Academy] as it relates to high-performing Japanese classrooms like this one. He closes with an alternate vision for Khan Academy that's provocative. You'll especially enjoy it if you find this #mtt2k business too mean-spirited. Commentary about that video belongs *on that video's YouTube page*, though. All comments about it here will be shot on sight.

Featured Comment

[Chris Taylor]:

> Totally at the effectiveness of leaving the title to the end. The students not only see it because the content of the lesson is played out if front of them, but there’s a pretty clear agreement that the title of the lesson fits. One of the students even says, “Cool.” How often do you get a student saying cool when you *start* a lesson by writing the title on the board.

[LOA] Concretizing Abstraction

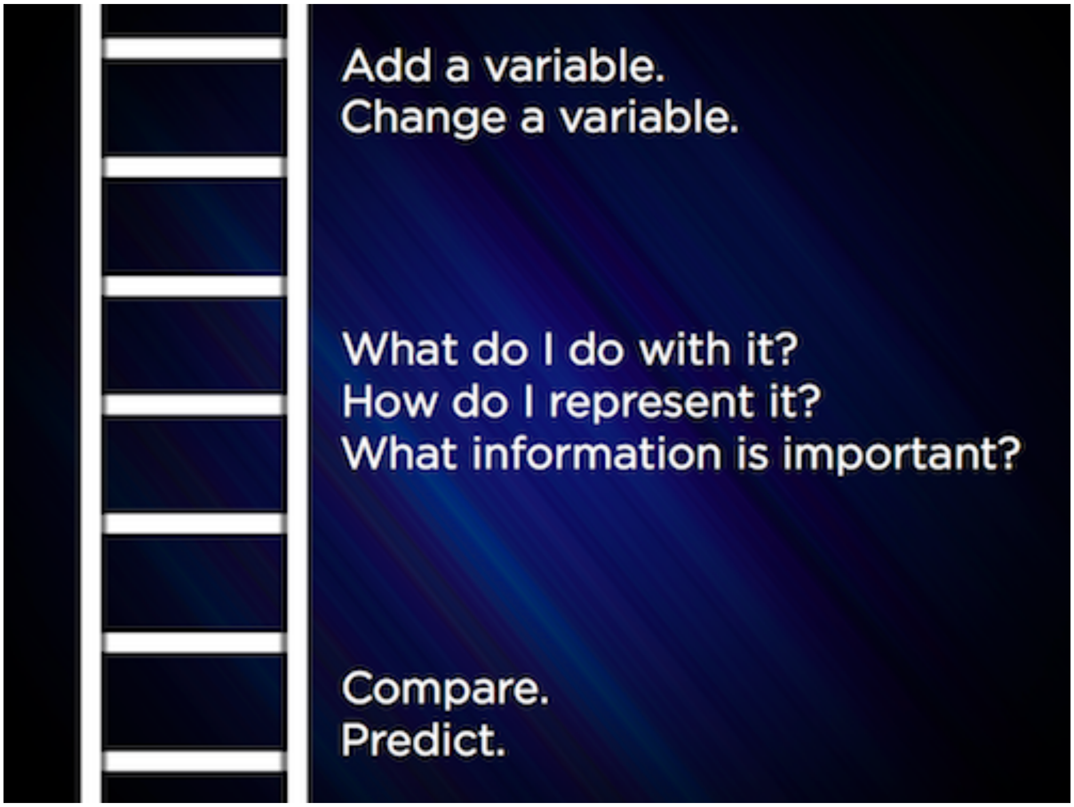
Posted in loa on July 25th, 2012 24 Comments »

Let's drop down a rung and make abstraction concrete.

You're walking across a street. This is a photograph of what you see.

This is your context. What is its abstraction? There's no way to know because you don't know your purpose here, your question.

You ask yourself, "What colors do I see?" Now you have a question and you're on the ladder of abstraction.

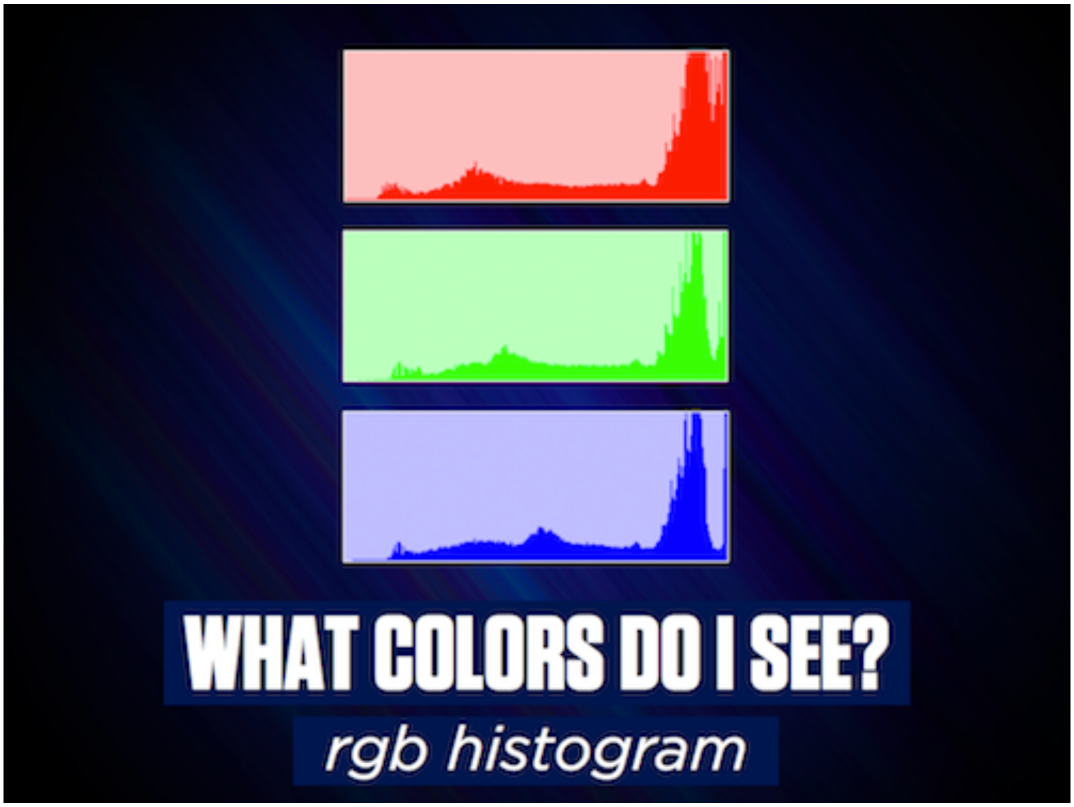


You start speaking very informally about the context, perhaps comparing one shade of green to another. You ask yourself, "What's important here?" and decide it doesn't matter whether the green thing is a car or a tree. All that matters is its greenness. This is abstraction. You're removing aspects of the context that are inconsequential to your question.

Now you have to decide how to represent the consequential aspects. You could represent them with words:

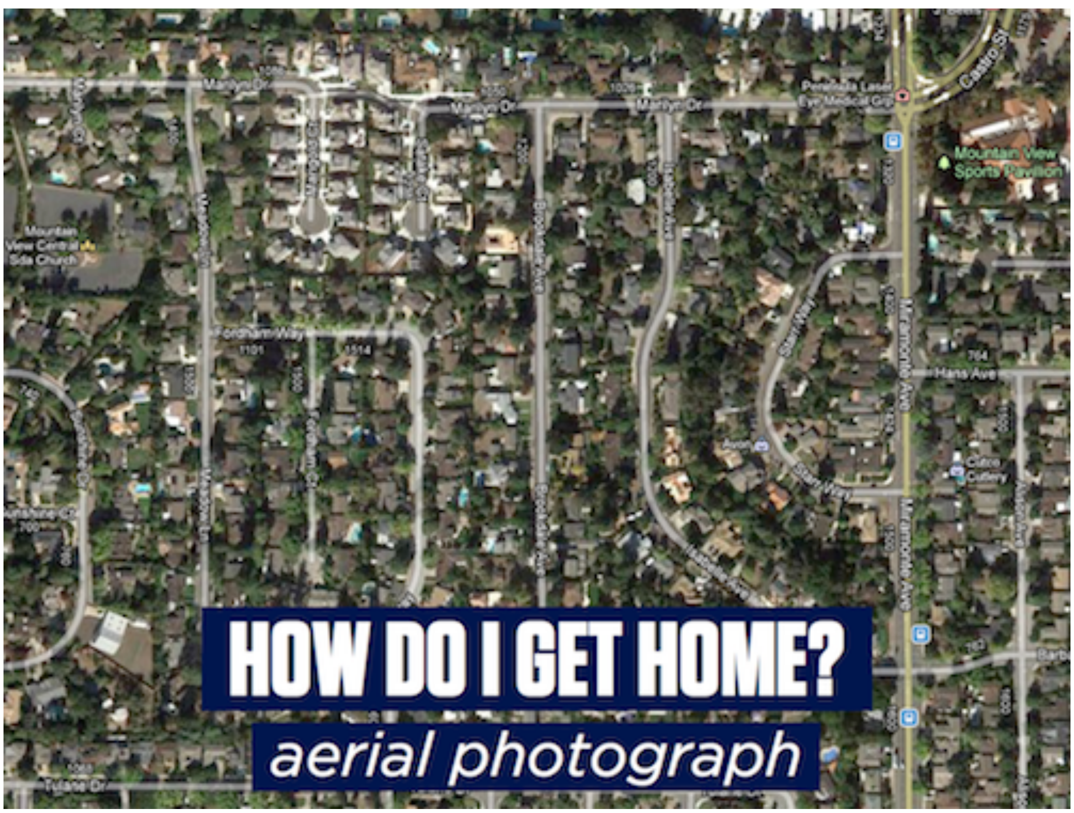
> A lot of grays on the street and sidewalk. Light blue in the sky. Red on the curb. Different shades of green in the trees and on a car.

Different representations are more useful for different purposes. This representation might work if you were writing some prose about the colors. If you wanted a more precise representation, though, you might turn to a histogram of the red, green, and blue values.

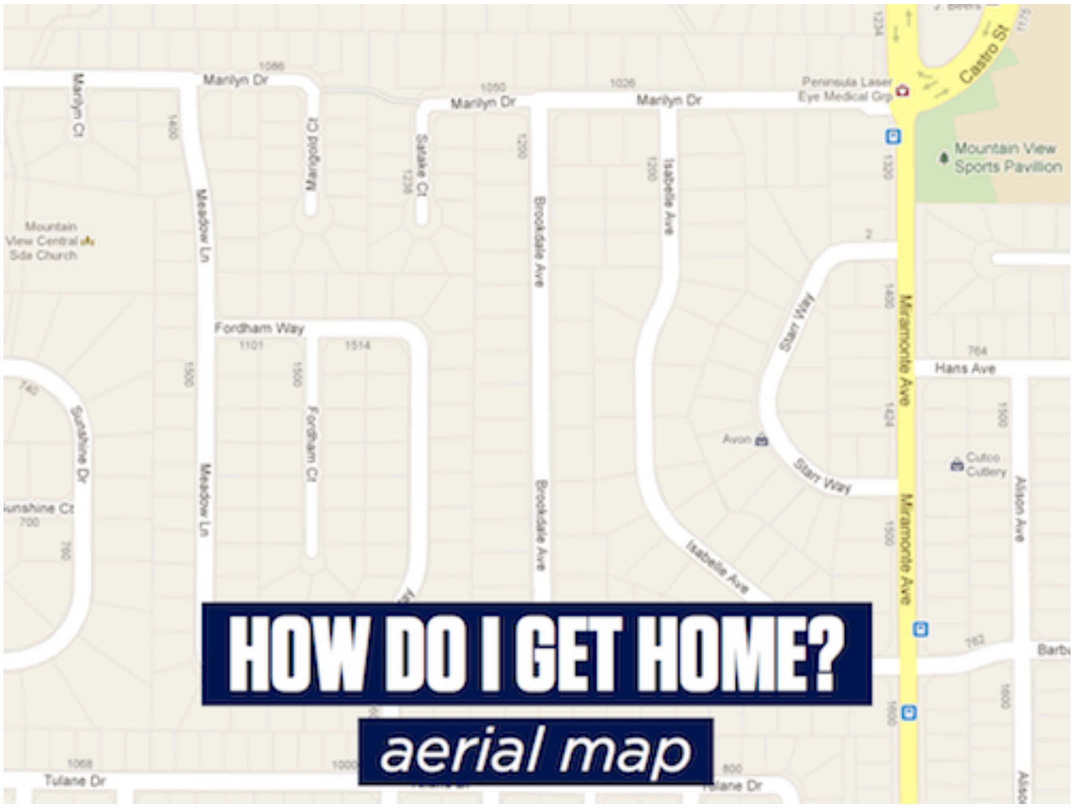


Now if the question changes, the entire ladder changes. If your question is, instead, "How do I get home from here?" different predictions are useful, different information becomes consequential, and the representations of that information will look nothing like the histogram we used to examine color.

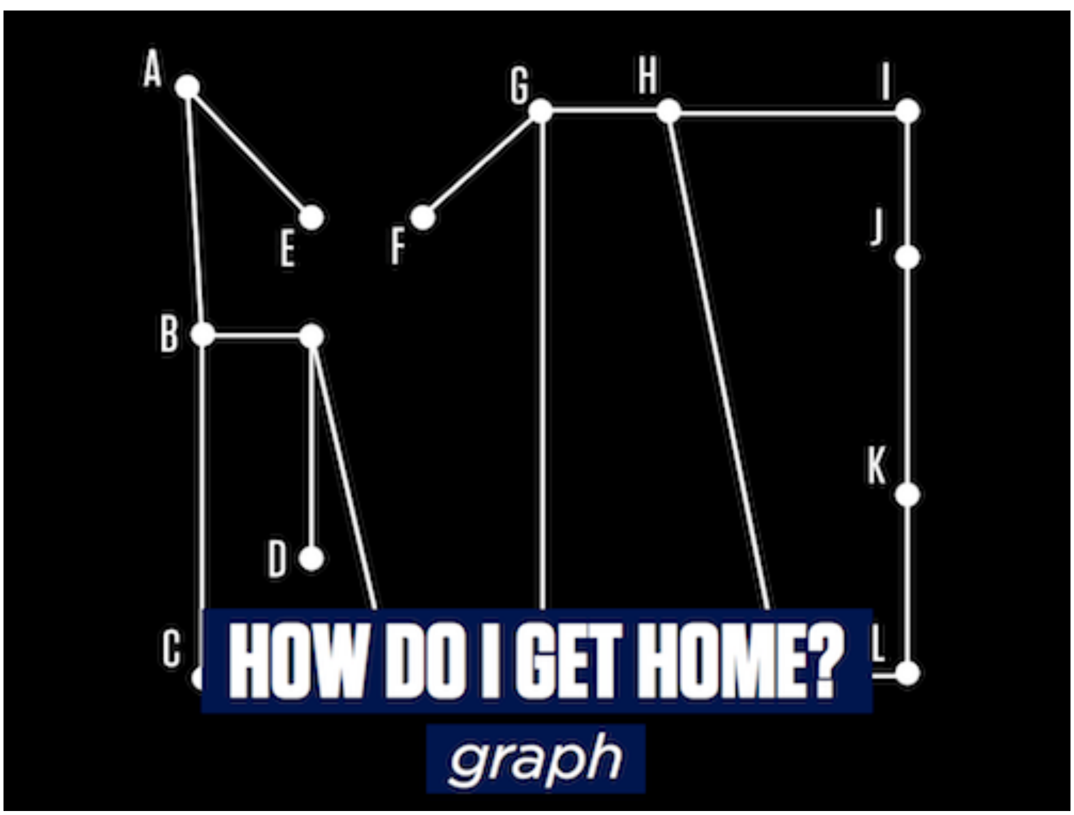
A useful abstraction of this scene would be an overhead view of the terrain.



Of course, we only care all that much about the roads, not the trees or houses in between them, so we abstract all that away.



If our purpose here is to create some kind of [enormous geolocation system](), we don't really care whether or not a road curves. We just care whether or not the road connects one intersection to another, or, abstracting those terms a little, we care whether or not an edge connects one vertex to another in a graph:

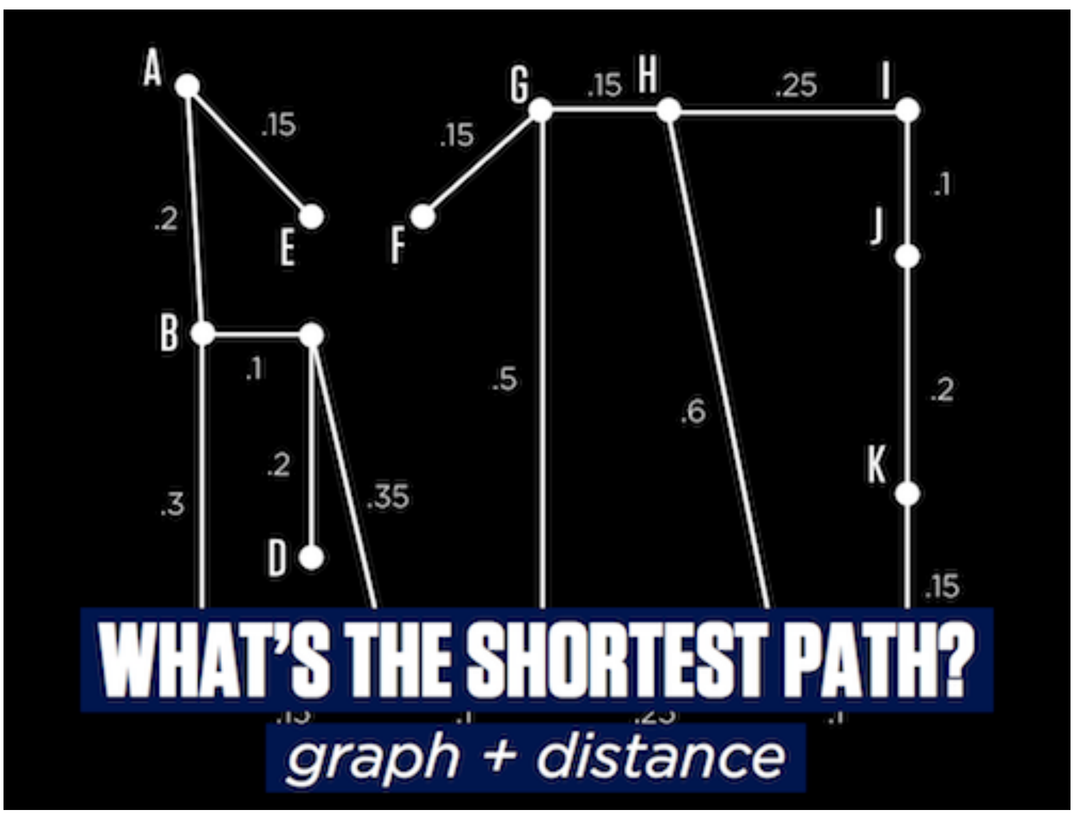


An array would be a representation of the graph that's friendly to manipulation by a computer, though as a human, I miss a lot of the visual information we've abstracted away.

BEGIN	END
A	E
A	B
B	P
B	C
C	O
D	P
F	G
G	H
G	N

BEGIN	END
H	I
H	M
I	J
J	K
K	L
L	M
M	N
N	O
O	P

Great. But not perfect. This representation will only tell us whether or not it's *possible* to get from one point to another — whether a route exists. If we want to find the shortest route, we add another useful variable, "abstracting over distance," at it's said.



If we want to find the *fastest* route, we'll also need to abstract over the speed limits of each of those edges.

That's a concrete example of the process and ladder of abstraction. The adjectives "concrete" and "abstract" just aren't all that useful here. Everything is concrete if you think about the rungs above it and everything is abstract when you think about the rungs below it. The photograph that kicks off the post is more concrete than everything that comes after it but it's also more abstract than the full-bleed, full-audio, moving panorama you experienced as you walked across the street. What matters isn't the rung itself but how deftly you can move between all the rungs above and below you on the ladder of abstraction.

Checking For Understanding: Give an example of abstraction as it exists in your own life, in the problems you or other people try to solve. Two examples to kick off our list:

- *Airplanes landing at night* don't care about the color of the tarmac or the grass on either side. All they care about are the margins of the landing strip, which are therefore lit up by lights.
- *Google's self-driving cars* abstract away a metric ton of data that your senses usually take in while driving — the color of the sky, the music in the car, the humidity outside, etc. It also *retains* a metric ton of data, of course, and the quality of Google's abstraction of the roadway will determine whether these things will kill us or let us (once again!) text while driving.

Featured Abstractions

Bob Lochel:

> *Should I call or text?* If the message is short and quick, I could just shoot a text, but what is my data plan like, and are there financial considerations? Or I could call, and risk a phone conversation which I perhaps don't have the time or want for at this point in my life? How important is the message? Or will I possibly see this person soon anyway and it's all a moot point? Or maybe I could just tweet it? But how sensitive is the message?

Max Ray:

> One way I can see abstractions is to think of domains where I'm not an expert. Is it an abstraction when two kids who are really into video gaming communicate their solutions to challenges in terms of button pushes rather than the story on the screen? As in, I'm likely to say, "Gee, I wish I could make Mario jump up and do a flip in the air to get that gold coin without being hit by the hammer." Whereas a Mario expert is likely to tell a fellow expert, "That level's easy. It's just right-right-A-left" (or whatever).

lessano:

> When looking at my email inbox, I disregard most of the information presented there. During the busy workday I "see" only the messages that are highlighted as unread and which were sent to me individually rather than schoolwide. This level of abstraction sometimes presents problems, so if I've read an important message but haven't yet resolved it, I have to star it AND mark it as unread, tricking it back into the category that registers.

Featured Comment

Bowen Kerins:

> One thing a great context / question also gives you is the experience of figuring out what information is important and what sort of abstraction is most useful for extracting and using the right information thoughtfully. And that's a skill a lot more adults will use than factoring.

Richard Bitgood, via e-mail:

> Transformations is one step higher than functions because it is the abstraction of our abstractions.

2012 Aug 26. Of course, *money* is an abstraction of the value we provide society.

[LOA] Abstracting Abstraction

Posted in loa on July 24th, 2012 4 Comments »

or: *Titles Guaranteed to Murder Your PageRank*

As I mentioned previously, I find the verb "abstract" way more interesting than *the adjective* "abstract." The adjective is often used critically and defensively ("Ugh. Algebra. Too abstract.") whereas *the verb* represents a milestone in human cognitive development and a skill that grows more and more precious in the modern workforce. How many skills have a shelf life of *thousands of years*? (A: Not typesetting.)

So let's define the verb:

Wikipedia:

> Abstraction is a process or result of generalization, removal of properties, or distancing of ideas from objects.

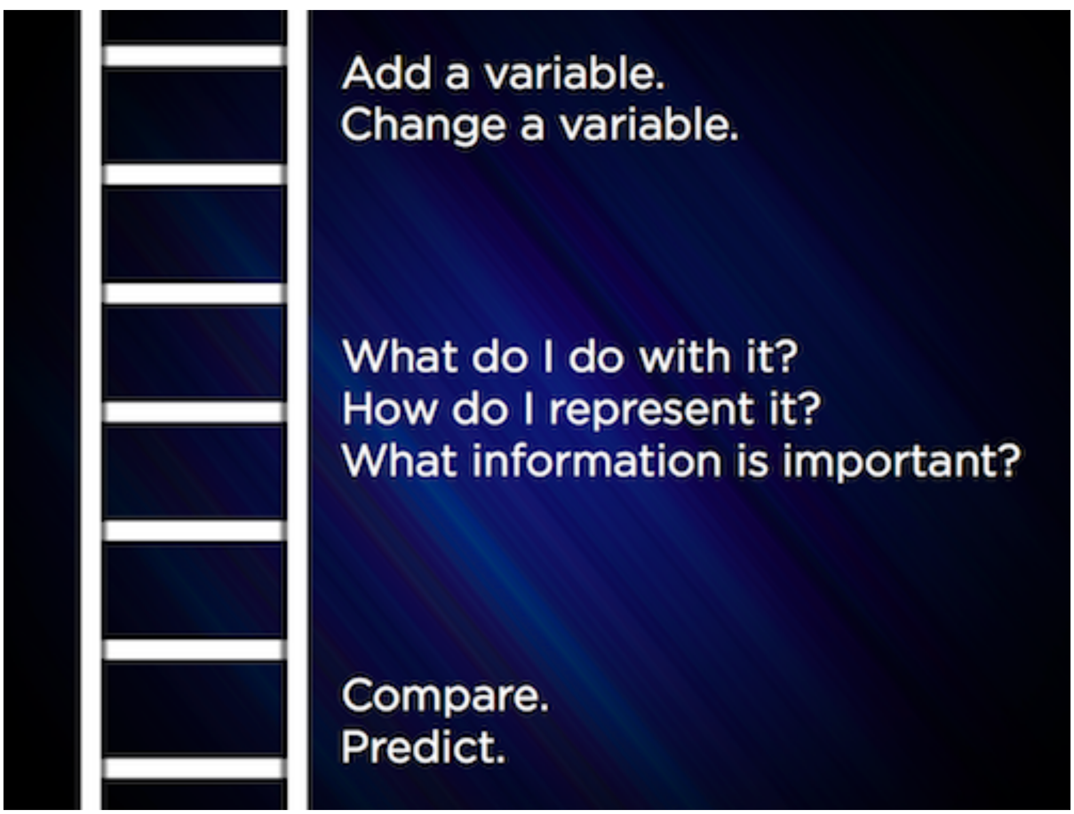
American-Heritage Dictionary:

> To take away; remove.

Let's stipulate, then, that abstraction requires a context and a question.

If you're going to remove stuff, there has to be stuff to remove. (A context.) If you're going to remove stuff, you have to have some purpose that tells you to remove this stuff but not that stuff. (A question.)

Then you're on the ladder. As you go up the ladder you turn the context into something that excludes the noisy richness of the context but which is much more useful for answering your question. As I looked at all the times my students have abstracted in math class, I saw that the tasks and questions we confront and their order look a lot like this:



We debate the context on the level of experience and intuition. We make predictions. We compare different examples of the context until we understand which of its aspects are common and consequential to our question and which aren't. We give those aspects names. We decide how to represent them. We decide what to do with those representations. And then we abstract other things in the same context.

If my mind were "light and deft and beautiful" as a monkey in a tree, I'd stop abstracting abstraction here, step down a few rungs on the ladder, and concretize this abstraction of the process of abstraction with an example. That's next.

Next »

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- Twitter
-

- ## My Curricula
  - Algebra
  - Geometry
  - Three-Act Math
- ## Tags
  - ## Categories
    - 3acts (21)
    - anecdotes (80)
    - anyqs (21)
    - assessment (34)
    - classroom management (45)
    - conferences (57)
    - contest (37)
      - four slide sales pitch (14)

- mtt2k (1)
- my annual report (20)
- design (232)
  - digital instruction (76)
  - digital storytelling (19)
  - information design (49)
  - keynotecamp (1)
  - presentation (28)
  - redesigned (12)
- dissent (4)
- guest blogger (9)
- help wanted (2)
- howto (2)
- interview (3)
- itgotaway (3)
- lessons (86)
  - advisory (1)
  - algebra (37)
  - ela (9)
  - geometry (29)
  - review activities (4)
  - science (4)
  - social studies (3)
  - vapa (4)
- loa (7)
- mailbag (19)
- new teacher lab (6)
- ontheroad (4)
- pseudocontextsaturday (29)
- series (133)
  - design for educators (3)
  - dy/av (20)
  - how i work (6)
  - how to present (7)
  - what can you do with this? (99)
- show and tell (30)
- tech contrarianism (85)
- tech enthusiasm (61)
- uncategorized (361)

Archives

- August 2012 (9)
- July 2012 (10)
- June 2012 (9)
- May 2012 (16)
- April 2012 (13)
- March 2012 (10)
- February 2012 (10)
- January 2012 (9)