I really appreciate your support of my class. Is a straw a simple machine or not? This question was pondered yesterday. The class is split. Many of my students say no because “the straw relies on pressure”. Others have claimed that it would be an inclined plane. We are looking forward to reading your responses. Thanks again
Mr. T’s class (Michael Thornton- @mthornton78)

When the class first asked my initial reaction was “no” because the force (“suction”) was separate, but the for ce is separate with an inclined plane, a screw, a lever. Simple machines aren’t “machines” as we usually mean but tools which re-direct forces. As a lever shifts a downward force into a lifting force, a straw converts a generalized suction into
Ira Socol

From our staff scientist Martin Weiss:

Simple machine are defined as a mechanical device that changes the direction or magnitude of a force. So a lever for example moves a weight (force downward) in another direction (upward). In general, they can be defined as the simplest mechanisms that use mechanical advantage (also called leverage) to multiply force. It does not seem to me, to a biologist that sucking on a straw to move liquid upward is in the class of simple machines. Also, simple machines were defined during the Renaissance and I don't think straws existed then.

A google search yielded lessons using straws in building simple machines but none describing a straw as a simple machine.
http://www.google.com/search?client=safari&rls=en&q=straws+as+simple+machines&ie=UTF-8&oe=UTF-8

Question for Martin Weiss: *How is an inclined plane different from a straw? An inclined plane does not multiply force, it simply allows that force to be used efficiently in a single direction. So,as the alternative to the inclined plane simple machine is to lift, the alternative to the straw is to lift (think spoon, or lifting the glass). Also, whether or not something existed during the Renaissance doesn’t seem a valid scientific reason to rule something in or out of a category. We understand that there are planets beyond Saturn, for example, we understand that dinosaurs are related to birds. Michael’s students were all born in this century, and I think explanations should make sense within science, not historical cultural limitations.*

Martin Responds:

I merely added the historical context so that students who were born in this century should understand that these are not new concepts; that scientists have been dealing with them for a long time.

The issue of the simple machines is that a little bit of energy can effect something that requires,

with out the machine, much more energy input. I think Steve put it well:

(See Steve below)

From our Coordinator of Out-of-School Time Learning and long time science educator Georgette Williams:

With my limited physics knowledge it doesn't fit the profile of one of the existing simple machines, wheel & axle, pulley, screw, wedge or lever, However is doing work when you apply force to it, i.e. getting the liquid from cup to mouth. I am not sure how to measure if it decreases the effort and its not lengthening the distance the water has to travel which is what determines if work is easier. With all that said I would say no its not a simple machine.

From our CEO Margaret Honey:

How cool.... It seems to me you can turn straw into a simple machine.... think of using it to build a pulley. You could certainly use it as a tool..... He ought to give his class a definition of a simple machine and the definition of a tool and let them have a field day!

From NYSCI science educator and physics expert Adiel Fernandez

Might be tough (and only a partial answer) in 140 characters...

How about:
"Great question! A straw is not a simple machine because it doesnt change the amount or direction of the force from one end to the other"

From Steve Uzzo, Stephen Miles Uzzo, PhD. VP, Science & Technology

I think the problem is that simple machines are supposed to use a transfer of energy to do work, usually a small force over a larger distance to a larger force over a smaller distance. So for instance, a hydraulic press in which a small piston/cylinder transfers energy to a larger one to do work could be a simple machine--akin to a lever, block and tackle, or inclined plane, but a straw is a linear transfer of energy. There is no change in the energy versus distance within the straw on one end or the other-- The straw is not providing any "leverage." It is not a simple machine, by that definition.

I'm still confused. You are all comparing the straw to a lever or a pulley, in which force is multiplied. So maybe I'm missing something - not being a "science guy" and all, but how is force multiplied on an inclined plane? Doesn't an inclined plane save energy by replacing lifting with pushing? Doesn't a straw save energy by replacing lifting with suction? - Ira Socol

Related to IS's question: *Doesn't an inclined plane save energy by replacing lifting with pushing?*

When using inclined plane vs. lifting - both require the same energy from the user in order to move an object upward...though using the inclined plane would be "easier" in that it requires less force by the user. In fact, the person pushing something up an inclined plane probably uses *more* energy than the lifter, since she/he has to push to counteract friction between the ramp and box as well as push against gravity.

Example: Compare someone lifting a box from the ground onto a loading dock vs. someone else pushing the same box up a ramp. In both cases, the box has been given the same amount of energy (since they both end up at the same height). The difference for the lifter vs. the pusher is that the person pushing the box up the ramp applies a smaller force upward than does the lifter (though over a longer total distance). The job has been made "easier," though, since the ramp reduces the needed force.

OK, so, Compare moving liquid through a straw to lifting that liquid without the straw. Maybe the class can find online the caloric count of muscle use. The energy used to lift the liquid by picking it up (spoon, or perhaps tongue - dog-like) vs the energy needed to lift the liquid through ~~suction~~ breathing and lowering the air pressure in the straw. Has the job been made "easier"?

If the job has been made "easier" through ~~providing a "mechanical advantage"~~ the focus of the ~~suction~~ air pressure shift~~,~~ and this is a device which cannot be subdivided into other machines, do the students now see this as a "simple machine"? (*"mechanical advantage" is not - I have been told- part of the "Simple Machine" definition, as suggested in the blue above*)

A secondary question: Is the "classical" list valid? Are an inclined plane, a wedge, and a screw really different? If a "wheel and axle" is a "simple machine" isn't a pulley dividable? And to carry that further - do scientific classifications ever change as people learn more? [IS]

From Eric Siegel, VP and Chief Content officer:

two different questions:

1) can a straw be used as a simple machine? Yes, it can be part of a lever, an inclined plane or a pulley. They should try it.
2) Is a straw as it is usually used (to suck up liquids) a simple machine. I don't think so for the reasons given.

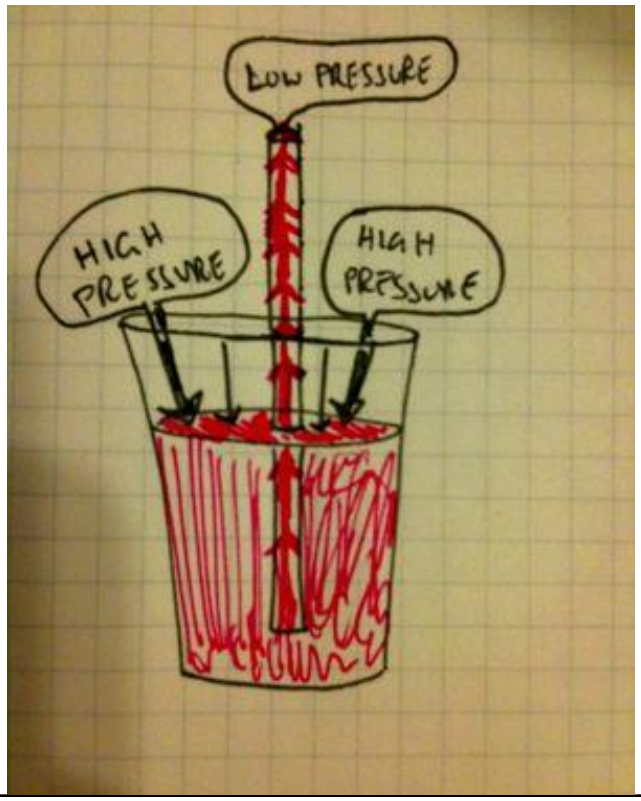
[Ira Socol] *I'll paste in this conversation:*

[me] We have a fight going on between - on one side, me and a bunch of third graders who claim that a drinking straw is as much a "simple machine" as an inclined plane, and - on the other side, Eric's NYHoS scientists and other third graders who say it isn't. Any thoughts?

[Kurt] good question... does it transform the direction of force or does it conform the direction of force? i would go with the later, so, technically speaking, it may not be a simple machine, but it is certainly a "fellow traveller" of the simple machine.

[me] There's the kids' question, which won me over. If it is different from an inclined plane, how so? Eric and company keep saying it isn't a lever or a pulley, but we already know that...

[Kurt] **i suppose it is a transformer... as it's area (in section) changes, so does the velocity. in so doing, it acts like a linear lever. i change my answer and am now firmly in the Socol camp.**
a lever really is velocity x force = work. a straw is doing the same thing. ***Note:*** Work = Force * Distance, where the two are in the same direction. Example: I pull up on a bucket of water to lift it a certain distance, and I've done work to the bucket of water.



tborash: Ok, you've "sucked me in" to the conversation! hahaha from mr .t's class

I've seen a lot about suction in these posts. Something about a straw to consider: in the words of my college mentor, *science never sucks*. It's all about differences in pressure.

When using a straw where one end is in the liquid and the other is at your mouth, there is now a system of liquid being "pushed on" by air (some air inside the straw, some outside).

As soon as you breathe in at the top of the straw, you remove the air inside of the straw. Since the air outside of the straw is still pushing on the liquid, the outside air forces the liquid up into the straw (and into your mouth).

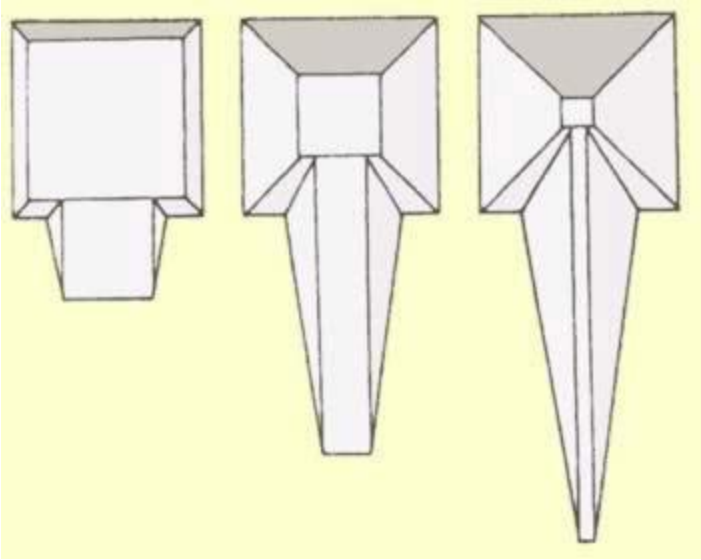
What I am now wondering is related to the questions related to inclined planes:

If a straw is at an angle vs. a straw that is straight up-and-down, does it result in less force required to push the liquid upward? - *in a vacuum situation, is angle anything more than a change in friction?*

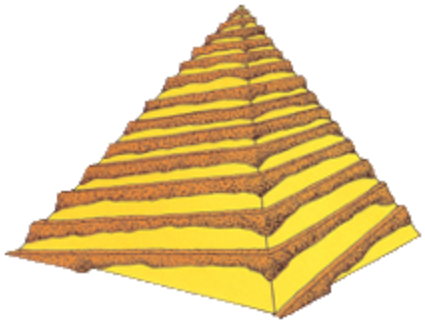
In other words, if everything else stays the same, does the **angle of the straw** make **moving liquid up to your mouth** easier? (This one makes me think of a inclined plane type of question...though it may be a little too difficult to measure properly!)

Test: What happens if a straw gets too big a diameter? Does it make it easier or harder to transfer the liquid using a set amount of energy (your lungs removing air from the straw)? What if the straw gets too narrow?

How does that compare to changing the angle of an inclined plane?



inclined plane in a guess as to how pyramids were built in Egypt



This ramp idea is different, but is it a different machine?

 and this ramp idea is different too, but is it a different “machine” than the inclined plane? Is it like another of the “classical” “simple machines”? it is a screw

from an off-doc conversation... [IS]

“Actually, the length of a straw does matter, but not a lengths we consider drinking straws. Rather than thinking of the sucking as a force applied at one end, it's better to understand that sucking is a reduction of pressure above the column of water, creating an imbalance with the pressure applied at the bottom of the column. The liquid is pushed up. But, of course, this can also be dismissed as semantics.

“Again - I suggest looking at the original question - "Is a straw a simple machine?" That question is provocative - because it leads to other questions. What is a Simple Machine? What does a straw do? How does it do it? There are several paths to a defensible answer to the original question. Here's one: Is a straw a machine? Can it be broken down into smaller elements which are each machines? If the answers are YES, NO respectively, then the answer to the original question is YES.”

From JP’s friend Jordan: “Yes, an inclined plane.”

Pam: Ok- I thought a straw could serve as an inclined plane machine or not-only having the potential to become a simple machine in that inclined state? Of course, I want the inquiry design to test whether the state of incline makes a difference in the force needed to suck fluid up the straw- then I wondered if the fluid being sucked might have any impact upon whether it becomes a simple machine or not in an inclined position (milkshake vs. water?) My sense of thinking the science is a bit rusty since I don’t get much of an opportunity to think this way in my current role- but Tony Borash and Becky Fisher sharpen that saw periodically..by the way how does thinking about this straw application relate to the Gulf of Mexico oil debacle from last summer?

@kjellstrom As it is typically used, I tend to say that a straw is NOT a simple machine. However, I can fold it in half and use the straw’s tendency to snap back to its original form as a mechanism to... flick a piece of crumpled paper toward a target. It would have to be a small piece of paper. I recall playing a version of paper football using straws (when I was much younger). In this instance, I would say that a straw could be a simple machine. I think that it all depends on how you use the straw (if you refer to the strict definition)!

@fnoschese here. I posed your question to some of my AP Physics teacher friends. Here’s one response:

“Well, suppose it is. Ignoring skin friction as the fluid moves up the straw (not a thick shake) then the straw will work without effort when it is horizontal but when vertical it will take a pressure differential (force in effect) that eventually equals the weight (see a multitude of arguments on this word) of the column of fluid. If the straw if tilted then the force is diluted BUT and the distance (vertical) is also reduced, actually making the total work less. A machine that not only reduces the pull force but also reduces the height lifted. Now that is a machine!!

The reason it decreases total work is that for normal inclined planes as the tilts away from vertical the motion plane must effectively get longer to reach the desired height.

Of course I have totally ignored the fact that as the straw is tilted, the whole cup must be lifted requiring work not only on the fluid but the cup as well which alas negates all the benefit except for the force along the straw. **Thus it is still a machine**.

I hope this analysis does not totally suck!!

-David Green”

I was never very good at answering some questions that begin with "is". I figured out long ago that if I placed *when*, *where*, *why*, or *how* in front of the *is*, I was able to see solutions I may have otherwise missed.

So my answer is yes. A straw is indeed a simple machine--a lever--when I'm at 7-11 enjoying a Slurpee using a straw like the pink one pictured below. With it, I can lift even the largest scoop of icy goodness simply by using the inner edge of my cup as the fulcrum.

- Chad Ratliff

Founding CEO of the New York Hall of Science, Physcisist Dr. Alan Friedman:

As Eric suggests, it is how you use an object, not what that object is, that classifies the object as a simple machine or not. As Eric says, using a straw as a lever, inclined plane, or pulley would qualify the straw as a simple machine or part of one. But as Steve point out, the argument has also been made that hydraulic systems should be considered simple machines (see Wikipedia on “simple machine”). Sucking up liquids qualifies a straw as a simple machine (of the hydraulic variety), in this case because the straw allows you to trade off volume vs. pressure between a large space (your lungs) and a smaller space (inside and just below the open end of the straw). That’s the same mathematically as the trade-off of distance vs. force for a lever. It is also why blow guns work.

But to my mind the problem here is with the question. It isn’t really about learning science as much as it is about memorizing old nomenclature which is barely useful for describing most

technology today. Defining a “simple machine” isn’t, IMHO, a very useful use of learning time, and standardized tests which look at this are not measuring anything very important. Our answering the question for the students doesn’t generate any important learning either—it just reinforces the notion that you should get your science from authorities, rather than figuring it out yourself.

I think the point of this activity is not clear to you. Your advice is the exact reason for having this activity. The students need to see that “simple machines” have a purpose. Even though there are only six “simple machines”, their purposes differ. In addition, I think it is very important for my students to find authenticity in their learning. A straw is an everyday tool for my students. Typically they look at it as a drinking transporter and that is it. Now they are evaluating what a straw does, how it works, and what it is similar and dissimilar to. Also, my students were going home discussing this with family, doing research in class and thinking well beyond the actual simple machines.

Reasons for this Doc:
1. Students are seeing first hand that scientist do not always agree (similar to their own experiences in school)
2. Students are taking their own ideas and comparing them to an actual scientist’s ideas.
3. Students are seeing that their learning goes beyond the four walls of a classroom.

Mr. Thornton

So I’d recommend responding to the students that the property of “simple machines” isn’t inherent in objects, but in how they are used. Dear students, think of all the ways you can use straws, and then classify each of those uses as simple machines or not. We’d be happy to discuss your classifications with you. That could lead to some interesting ideas, including some discussions which merrily challenge the usefulness of the term “simple machine” in the first place! This might take more than one tweet, which is also why so little important discussions of science (or of anything else) happens in tweets.

Cheers,
Alan

Alan, I’m not sure of what you are arguing “for” here. But I think you might be discounting the level of authentic learning which Michael’s class - and probably all children - engage in daily.

It seems to me that this class came to this question in the most authentic, scientific way. They took a concept - the simple machine - as presented and as experienced through experimentation - and then they combined that with basic observation of their environment (something missing from so much of our science education programs) and discovered another “simple machine” which, as Michael indicates above, they use every day.

So the question was never classifying random uses of an object - I can make a screw a lever - but the much more important issue of how classification works in science - in knowledge construction - and how that can limit our understandings of the world, and scientific progress.

If you look above you will see that most of the NYHoS staff first declared the answer based on a 500-year-old definition, which, yes, might give these students one more point on their state tests, but that was not the question.

Instead, through Twitter as an entry point (I'm unsure of the cause of your attack on that medium, it is like saying few great scientific papers are delivered by telephone - true, but...), and this document as a communication system, these students are now able to see that - in a critical way - their observations and analysis were correct (as you indicate), the bulk of the tools used to educate them are "wrong" (or, to put it better, tied to an antique classification system), that scientists can legitimately disagree, and that this is how 'knowledge change' occurs - knowledge base, observation, experimentation, challenge to existing hypothesis (often uncomfortable), new hypothesis, debate, experimentation, new consensus.

I know I'd love to see this doc on a "live screen" at NYHoS near an exhibit on simple machines, so others could join in. If we embraced that, in two years perhaps both New York and Virginia's tests might look different. [IS]

@fnoschese here: One more comment from another physics teacher friend:

> Supposing the straw is being used in the usual way.
> One could see a straw as being very similar to a hydraulic press. The fluid in the glass, outside the straw, has a large surface area compared to the fluid in the straw. Therefore the force applied to the outside fluid (due to atmospheric pressure) is much greater than that pushing the liquid up inside the straw. Correspondingly, the outside level of fluid drops much less than the rise in fluid level inside the straw. This appears much like the classic force and distance multiplier of a simple machine.
> At the other end, the lungs inflate by moving an even larger surface area (that of the ribcage) an even shorter distance. Since we have the combination of ribcage, straw and atmospheric pressure, I'm not sure the adjective simple applies any more, but looking at it this way I would classify it as a machine."
>
> Brian.

My third grade class answered this question by first taking a poll: The results were 89% say that yes, a straw is a simple machine (and this works out to 15 students in my class) and 11% (2 students) said that it is not. When they were asked to explain their thinking, the kids who said yes generally pointed out that it makes work, ie drinking, easier: "Instead of lifting it you just suck on it . . . especially if the drink is heavy" (Note to self: remember this at happy hour). One

student pointed out that it allowed you not to have to use your arms ". . . if you have a straw you can just sit there without using your arms." Of the students that voted no, the only comment to support that judgement so far argues that a straw is just something you drink from ("just a thing you use to drink stuff"). I will upload more explanations when we get them. Laurel Gillette, 3rd Grade This is awesome. Thanks. Mr T -

it's fascinating to me that such a simple question could generate this much dialogue, debate and tangential discussions of everything from the medium from which the discussion emerged to the complexities of defining the meaning of what some might say are relatively cut and dried scientific concepts. However, I am intrigued by the engagement of we adults in this as much as in following what 3rd graders are doing to "make sense" of how our invented technologies of the past still make work easier for us today. Having had the chance to "be" in Michael's room-perhaps in itself a reflection of "observer effect", I can tell you that his kids explore, question, reflect in powerful ways. Now, he's added a neighboring school in our county into the discussion mix. It's interesting how social media created an edu-web of thinkers linking 8 year old elementary children to who-knows-how-old mega Docs. When it's all said and done, we will have 1) a 3rd grade teacher who will have thought far more about the purpose of children expanding their understanding of simple machines than what Virginia asks of his kids on a 4-item multiple choice test, 2) a group of children who may not understand who all of us are, but who are fortunate to have a teacher who will sense-make our info with them 3) a group of adults who entered into this because we love the pursuit of scientific inquiry and see helping children find that same love as a great investment of our time... (Pam)