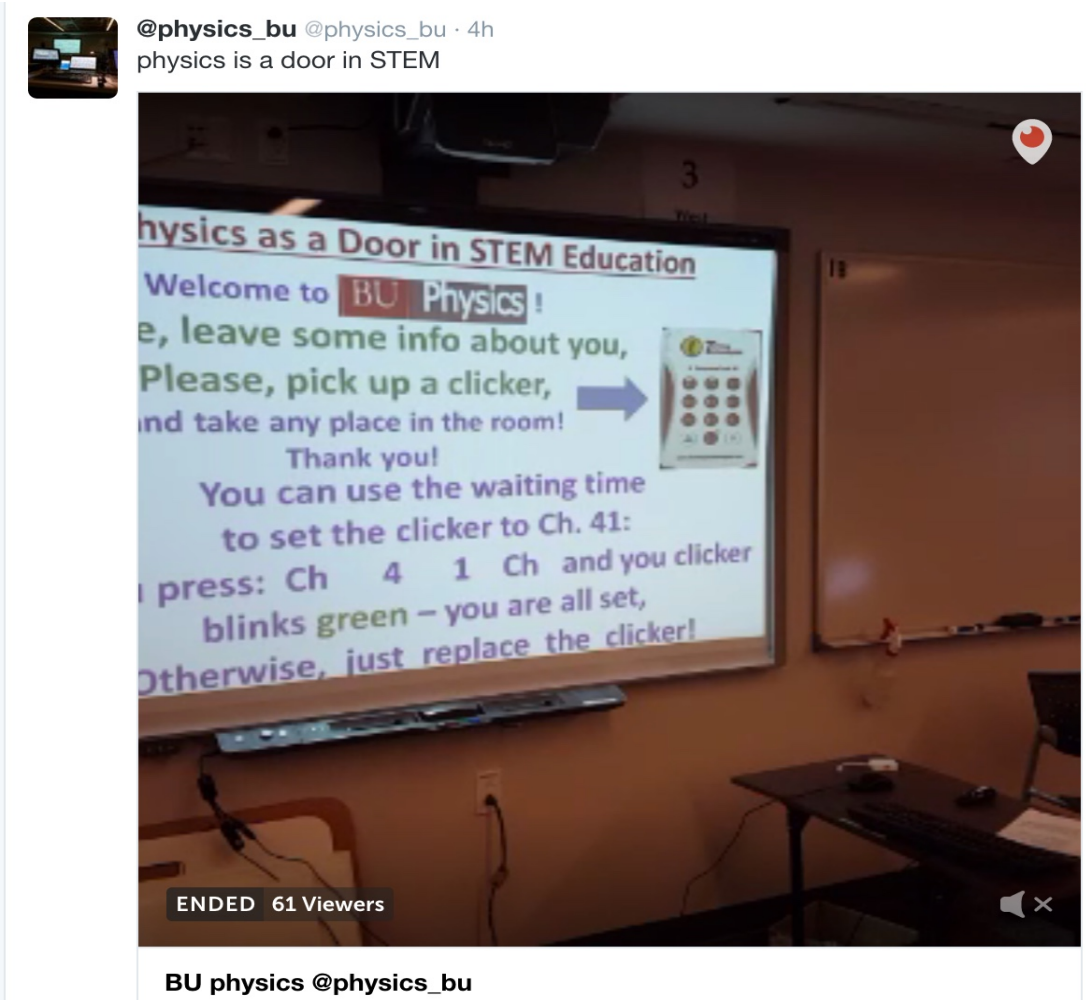
“Physics as a Door into STEM Education”

This presentation was a part of a seminar held at Boston University on January 17th, 2017.

This link leads to a 9-minute video highlights of the talk: https://youtu.be/xd3IM1cSASQ

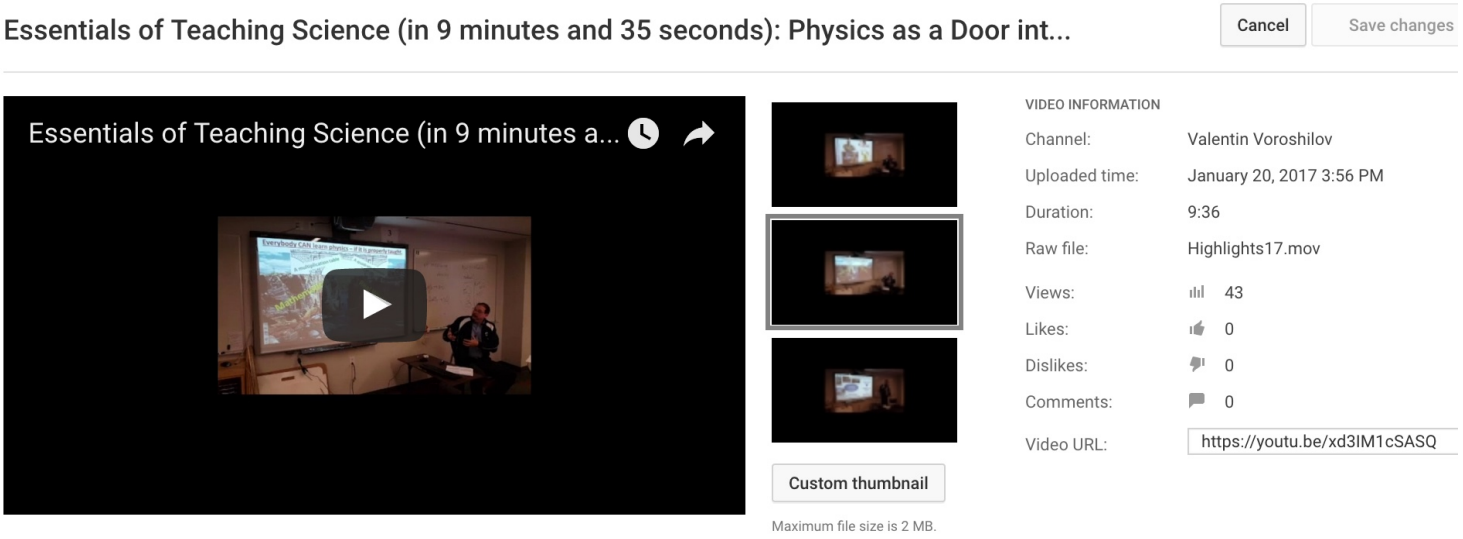
This link leads to a 1-hour video of the whole presentation: http://dai.ly/x58y9xy

The presentation was also streamed live via Periscope

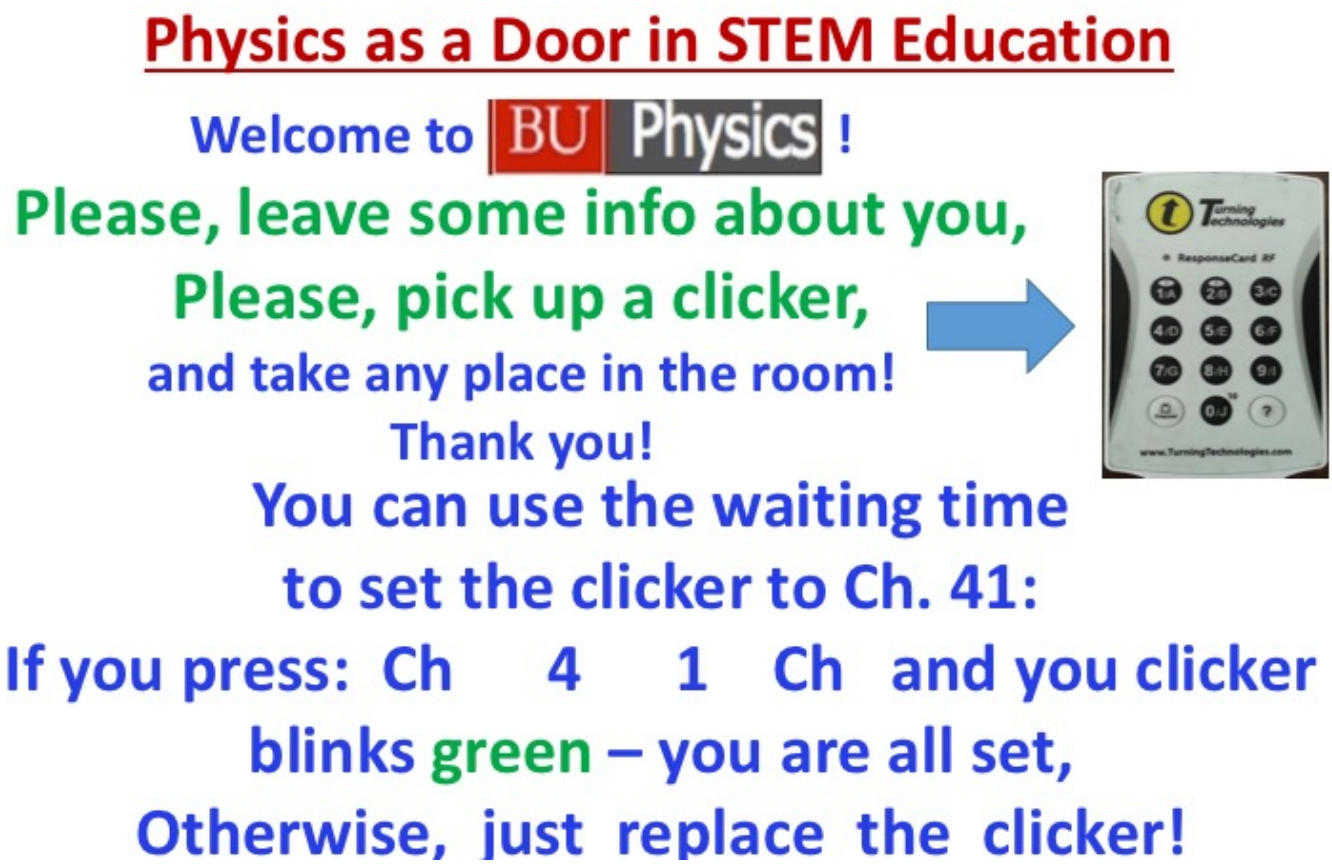


and Facebook.

The 9-minute video has had in two days more than 40 views.



1. Hello, and welcome to Boston University!



2. I'm Valentin Voroshilov.

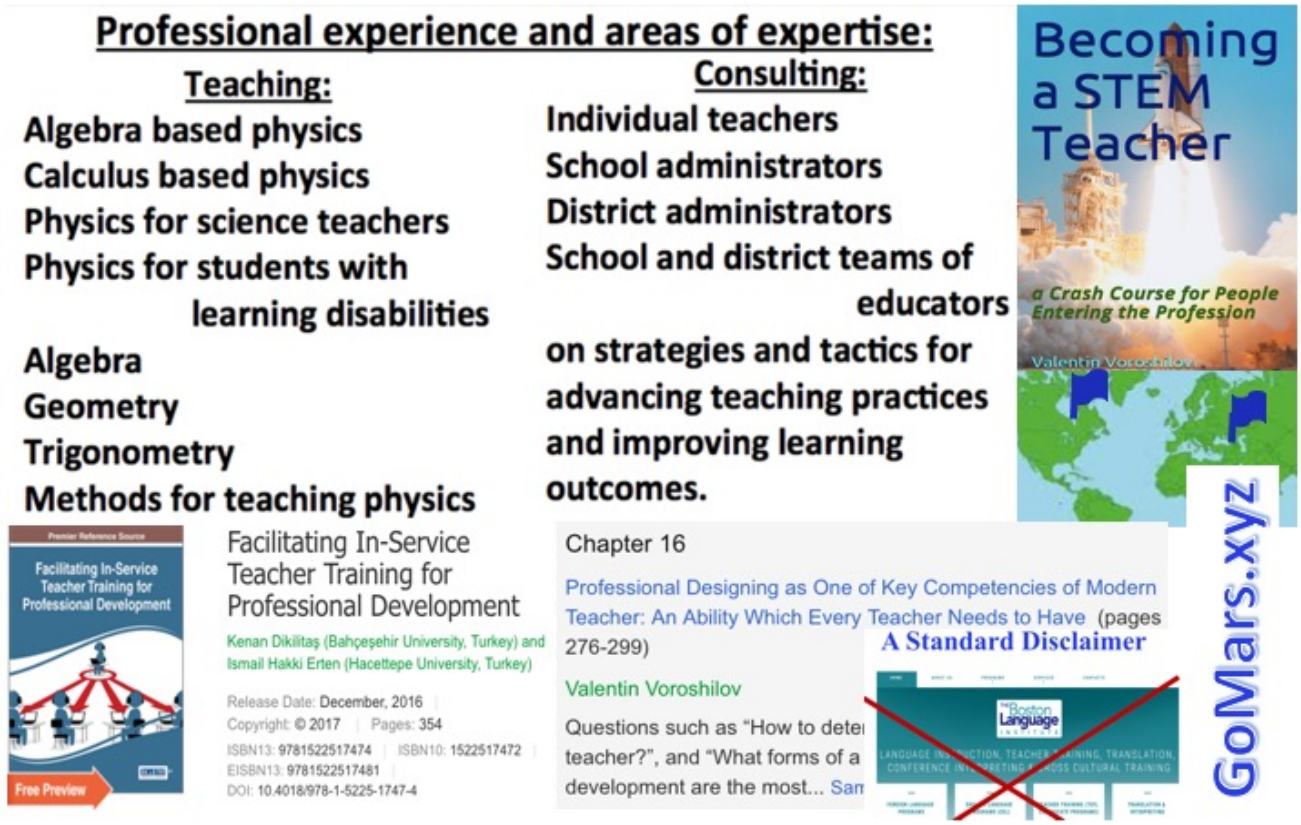
First, a standard disclaimer.

I have no formal education in English, I learned it mostly from radio and TV.

If at any point you start feeling that I speak Russian, just stop me.

And, of course, feel free to ask any questions.

All information about me you can find on my website www.GoMars.xyz



3. This event is being streamed. I use Periscope, Facebook, and also a regular camera.

I'm a paranoid about technologies. I always need a backup. And a backup for the backup.

The slides, all the links, and the video will be posted online.

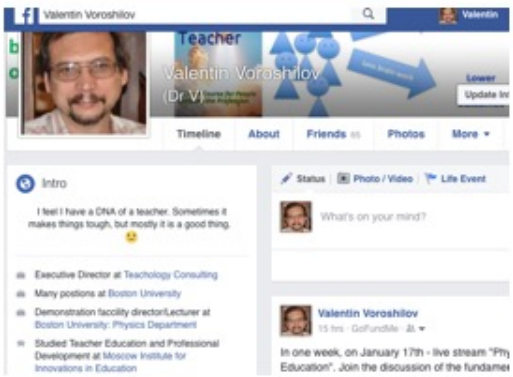
If anyone is watching now, please email me your questions or suggestions.

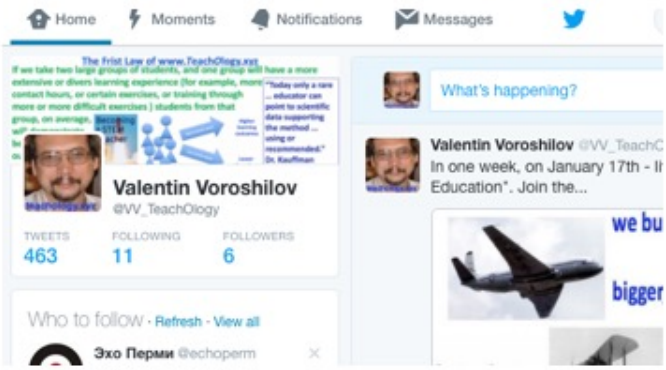
Please note that what you see on your screen is about 30 to 90 seconds behind of what is happening in the room.

Streaming (30 to 90 s delay)

Facebook

www.facebook.com/VVTeachOlogy





Twitter

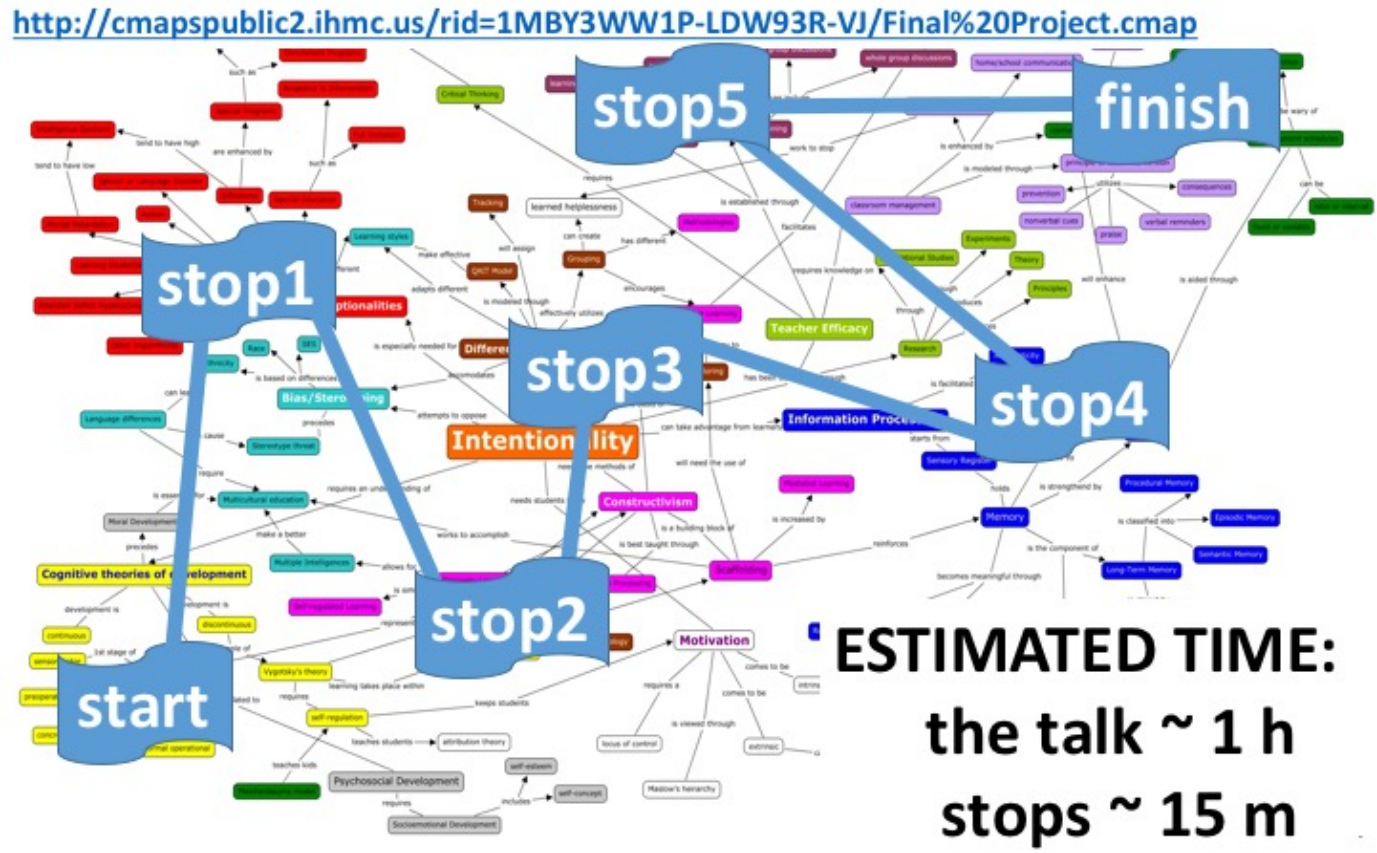
https://twitter.com/VV_TeachOlogy

my web site: GoMars.xyz

For questions/comments: valbu@bu.edu

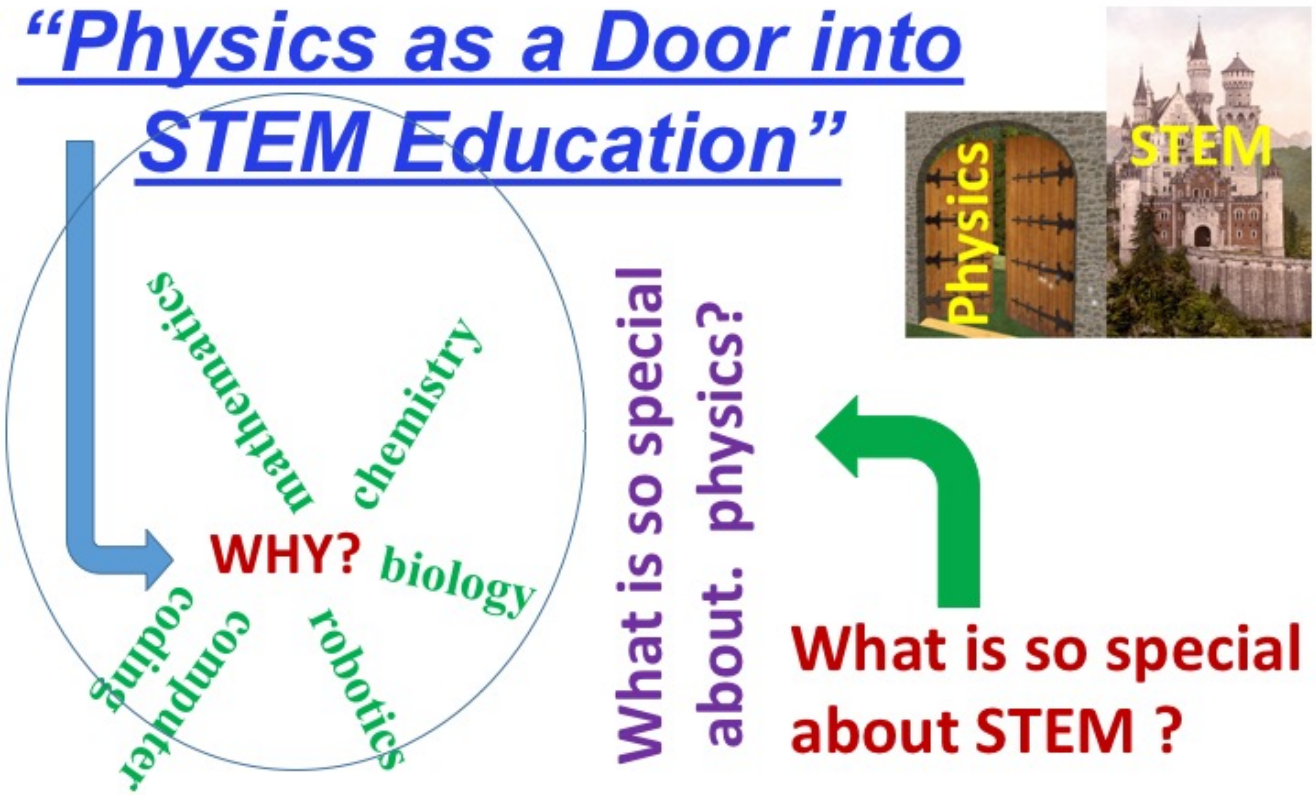
4. According to my estimation, my talking time should be close to an hour.

However, during the presentation, we will also make fours short stops for polling, and one stop to solve a problem.



5. Our main topic today is the role of physics in STEM education. The goal is to find out what is so special about physics? But first, we need to talk about STEM education in general.

What is so special about STEM education? Then we can focus on the place of physics in it.



6. This is our first stop. The first polling question. For online users, it is available at www.GoMars.xyz/stop1.htm Please, read and select your answer.

You just need to press a button on your clicker, and it should blink green.

And, of course, feel free to share your thoughts, especially if you pressed 8.

My answer comes in several slides. "I'll keep in suspense."

"What is so special about STEM education?"

Please, use your clicker to select an answer!

1. Nothing. **GoMars.xyz/stop1.htm**

2. A lot of mathematics.

3. It requires a special way of thinking.

4. Not sure.

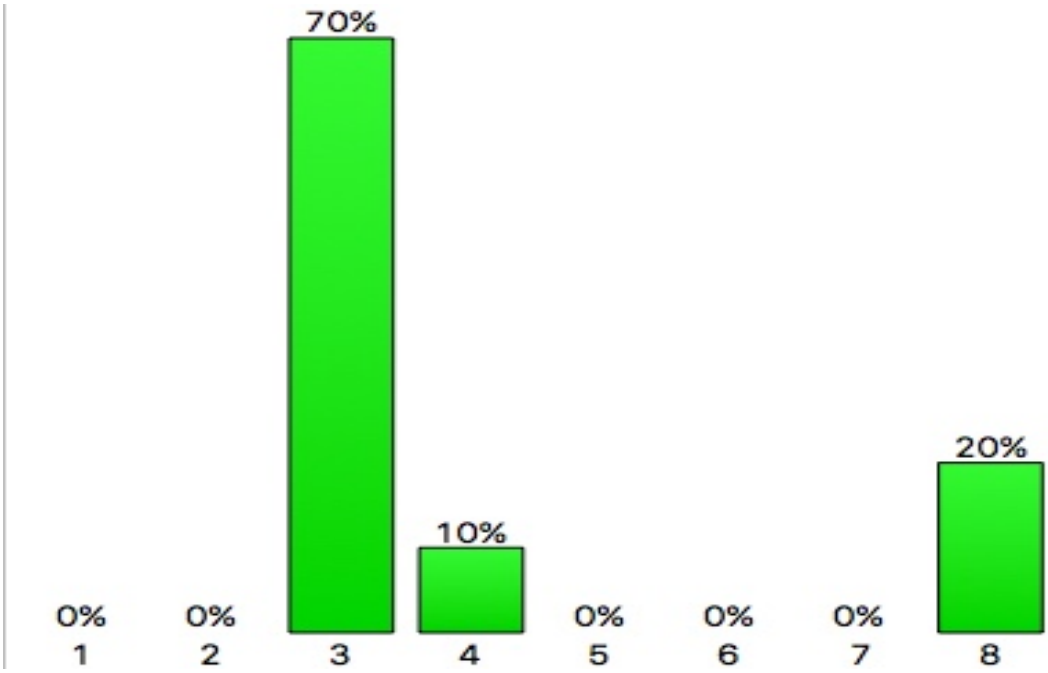
5. It is the only one team-based field.

6. It is only for men.

7. It is only for Asian and Russian children.

8. None of the above

STOP1: valbu@bu.edu



There is no right or wrong answer. There is an answer I like the most, there is an answer you like the most.

The fact that we have a distribution proves that different people have different views on the matter.

If I asked you to select the correct statement of the Newton's Second Law (how does the sound?) – we would have a unanimous answer. But in education we always have a variety of views.

7. First, I want to offer my logic.

I find very interesting to learn what *business* community says about STEM education. After all, those people are the consumers of STEM education! If you go to the Massachusetts Business Roundtable web-site, you can find many interesting documents, including a 2016 report, which says … this.

"Currently 75 % of MA employers find workers NOT ready for the tasks they need to do."

Massachusetts Business Roundtable

http://www.mbae.org/wp-content/uploads/2016/11/FINAL-Report-2016-MBAE-Employer-Poll-for-web.pdf

http://maroundtable.com/doc_reports/MBR_BEPreport.pdf

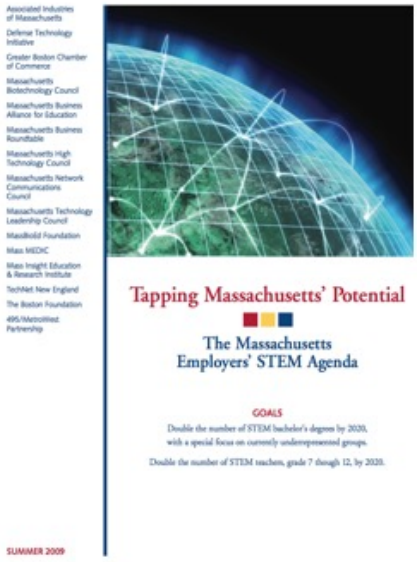
"According to a 2016 survey of 400 employers from across Massachusetts, 75% said that it was difficult to find people with the right skills to hire in Massachusetts." "Respondents find deficiencies in the readiness of new hires, not just in "applied skills" like teamwork, critical thinking and communications, but also in simple reading, writing, and math."

http://www.mbae.org/wp-content/uploads/2016/11/FINAL-Report-2016-MBAE-Employer-Poll-for-web.pdf

http://maroundtable.com/doc_reports/MBR_BEPreport.pdf

8. This is why 8 years ago, in 2009, MBRT established two very specific goals: One of which is "Double the number of STEM bachelor's degrees by 2020".

Massachusetts Business Roundtable



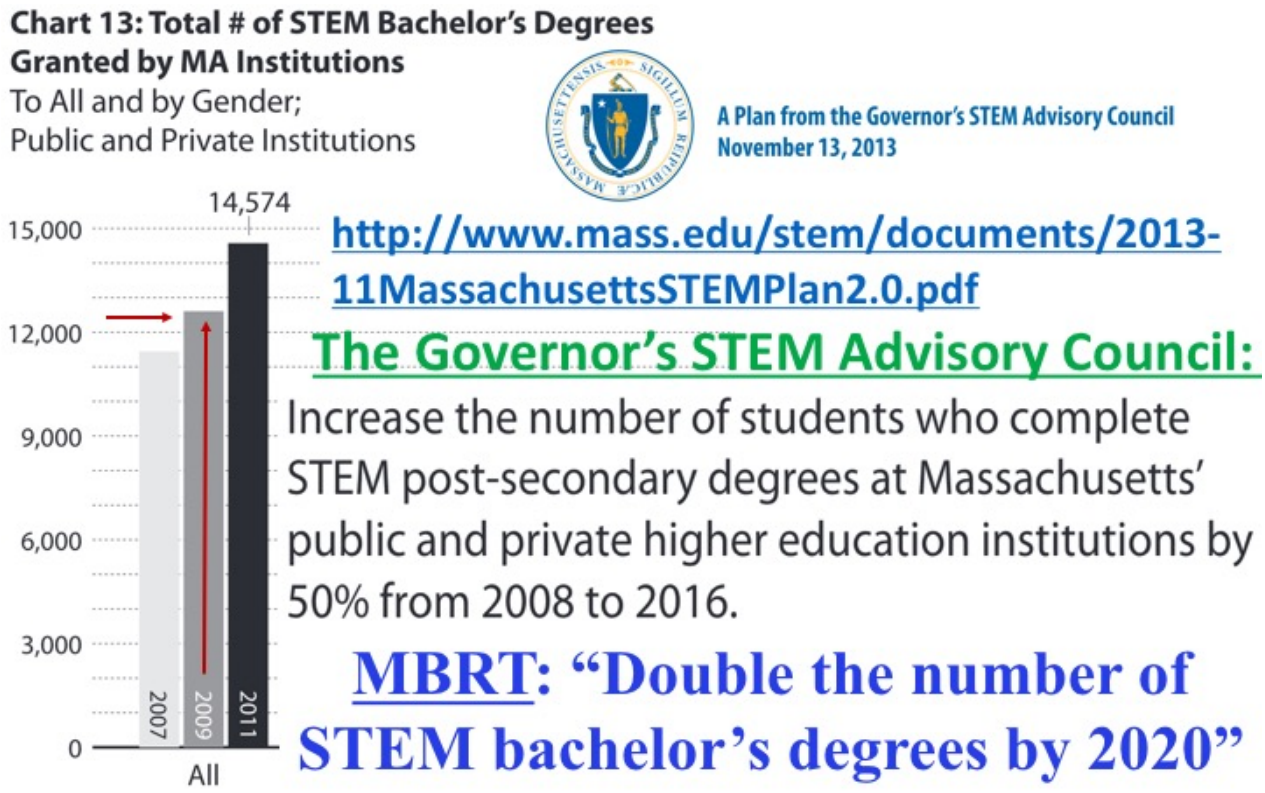
1. "Double the number of STEM bachelor's degrees by 2020"

2. "Double the number of STEM teachers, grade 7 through 12, by 2020".

http://maroundtable.com/doc_reports/0906_TAP_Report.pdf

http://maroundtable.com/doc_reports/0906_TAP_Report.pdf

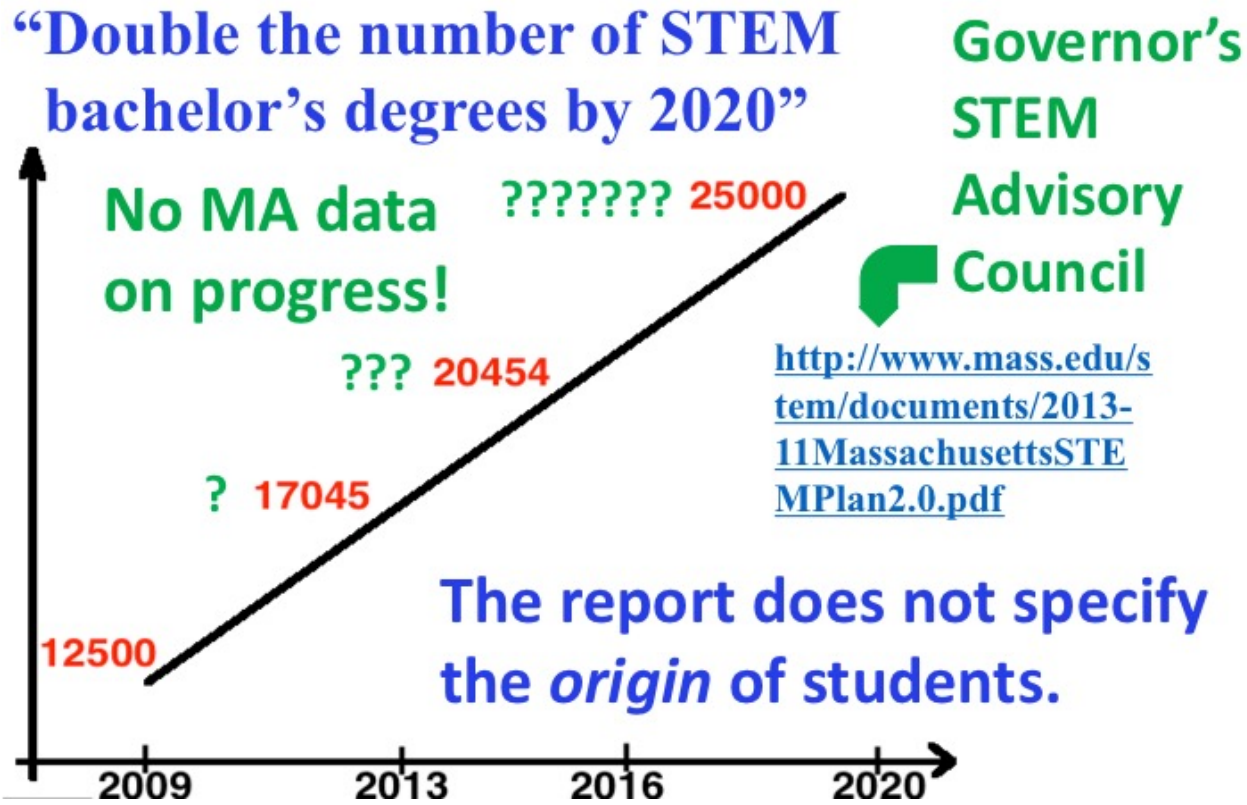
9. In 2013 a similar goal has been established by the Governor's STEM Advisory Council.



http://www.mass.edu/stem/documents/2013-11MassachusettsSTEMPlan2.0.pdf

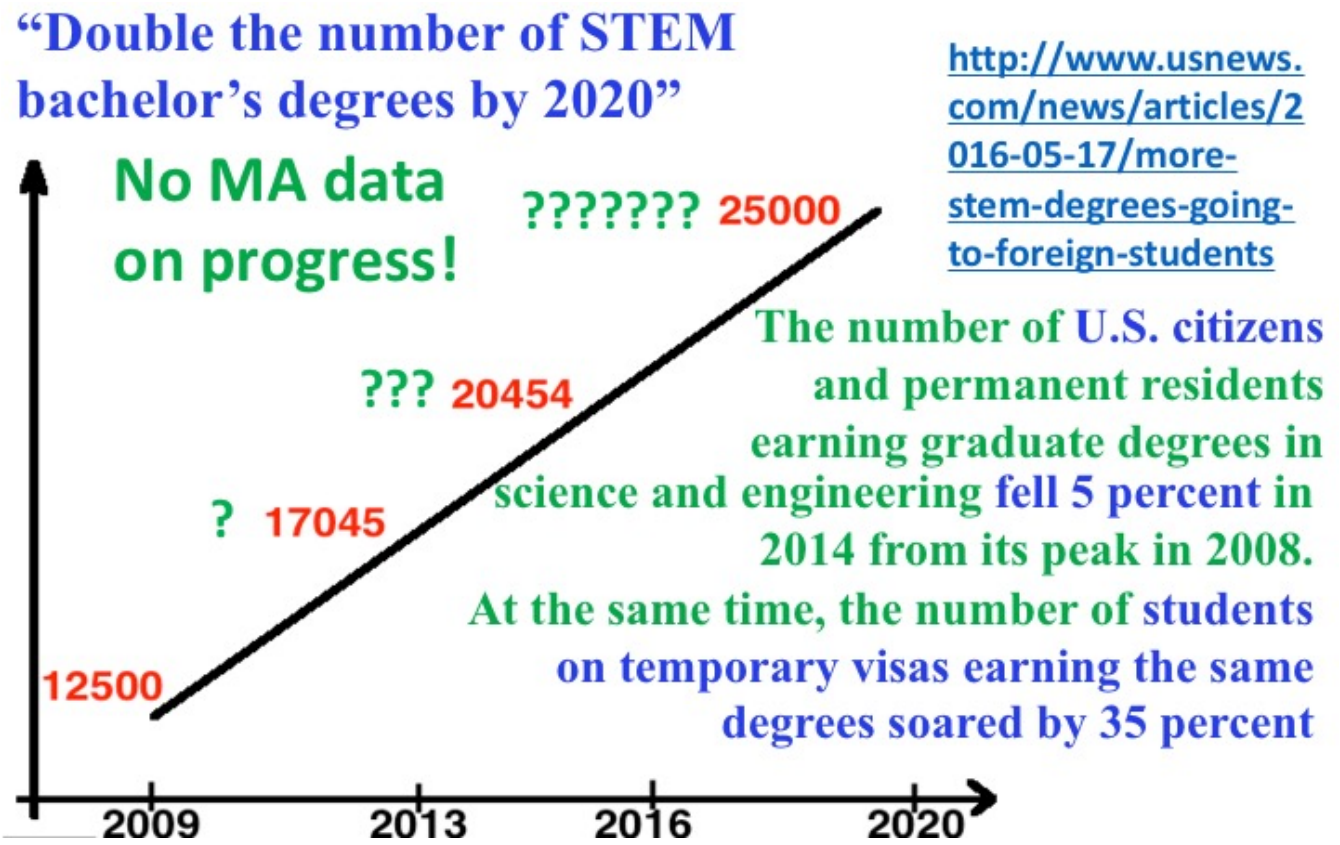
10. If we use a linear extrapolation between 2009 and the goal set for 2020, we see the projections for 2013 and 2016. However, no report has 2013 and 2016 Massachusetts numbers.

And by the way, documents are also not clear, if the graduates are born in Massachusetts, or in the US, or the number also includes graduates with foreign origins. And that makes a difference.



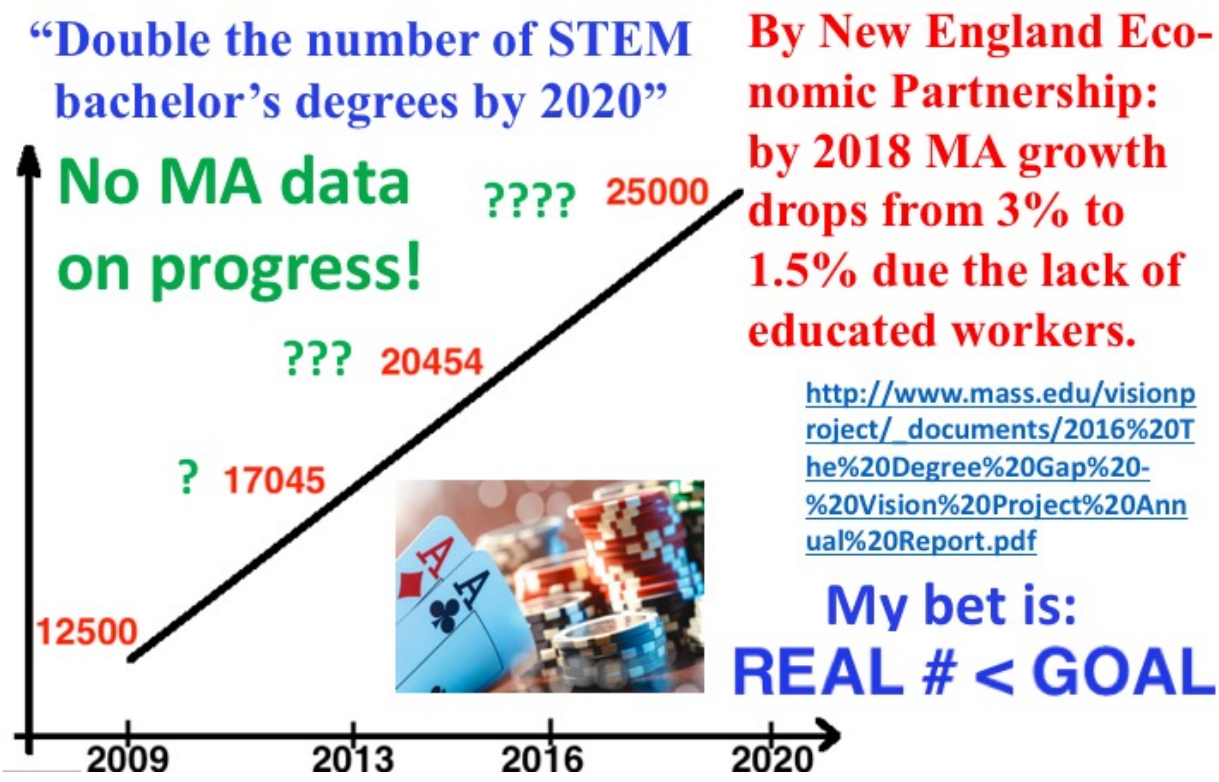
http://www.mass.edu/stem/documents/2013-11MassachusettsSTEMPlan2.0.pdf

11. I found some national data which shows that the growth in STEM bachelors comes mostly due to foreign students. The main concern expressed in many papers is not the fact that the US does not generate enough STEM graduates, but that graduates of foreign origins cannot stay in the US after the graduation.



http://www.usnews.com/news/articles/2016-05-17/more-stem-degrees-going-to-foreign-students

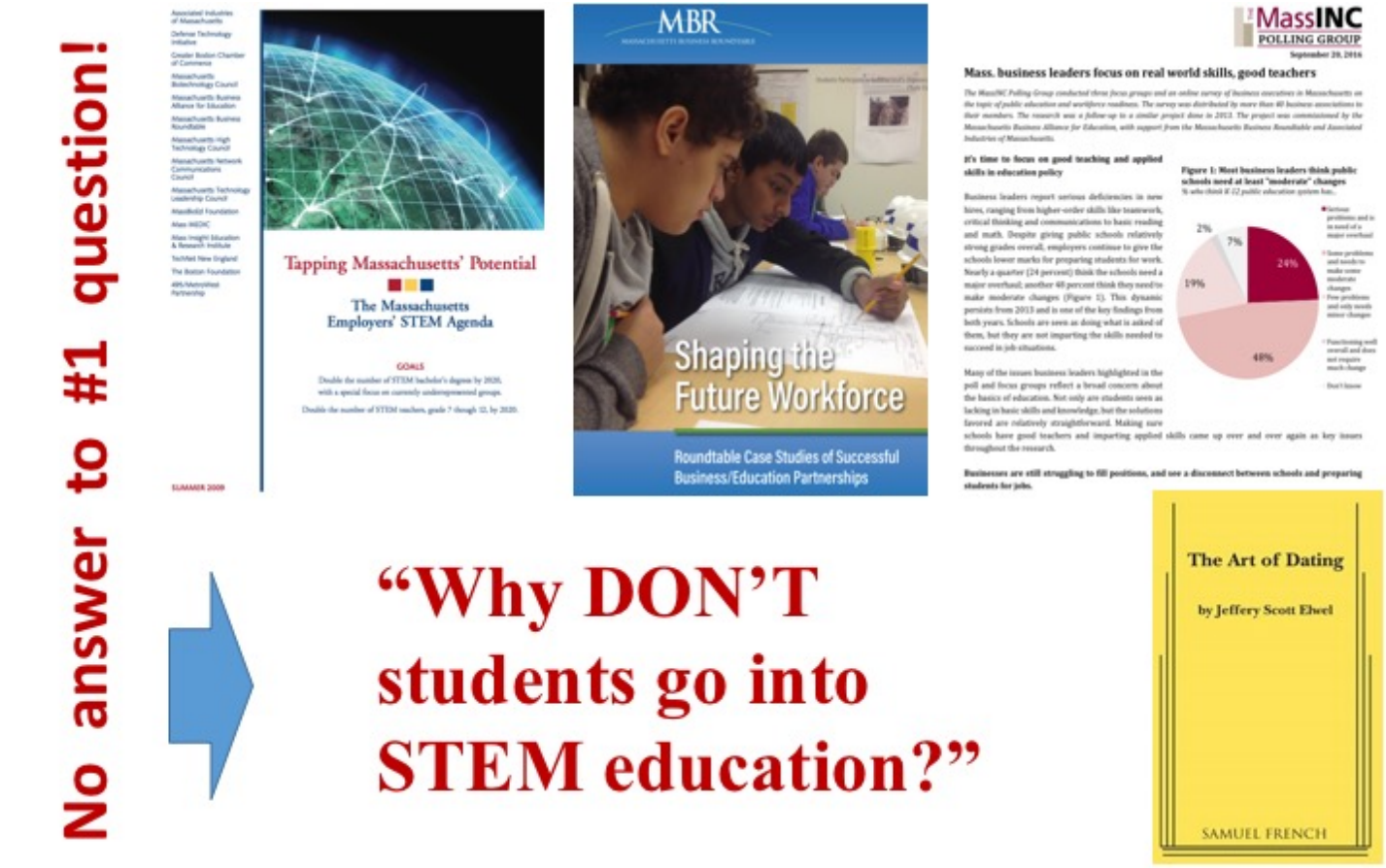
12. The New England Economic Partnership has some numbers on community colleges and state universities, and makes this statement. If we *had* data on ALL Massachusetts STEM graduates, I bet, the numbers would be lower than projected. Why?



http://www.mass.edu/visionproject/_documents/2016%20The%20Degree%20Gap%20-%20Vision%20Project%20Annual%20Report.pdf

13. All official documents on STEM education may have a lot of statistics, and good ideas, but miss one important question.

14. "Why DON'T students go into STEM education?" Trying to attract people into STEM without answering *this* questions, is like trying dating without asking "Why all girls leave me after the first date?"

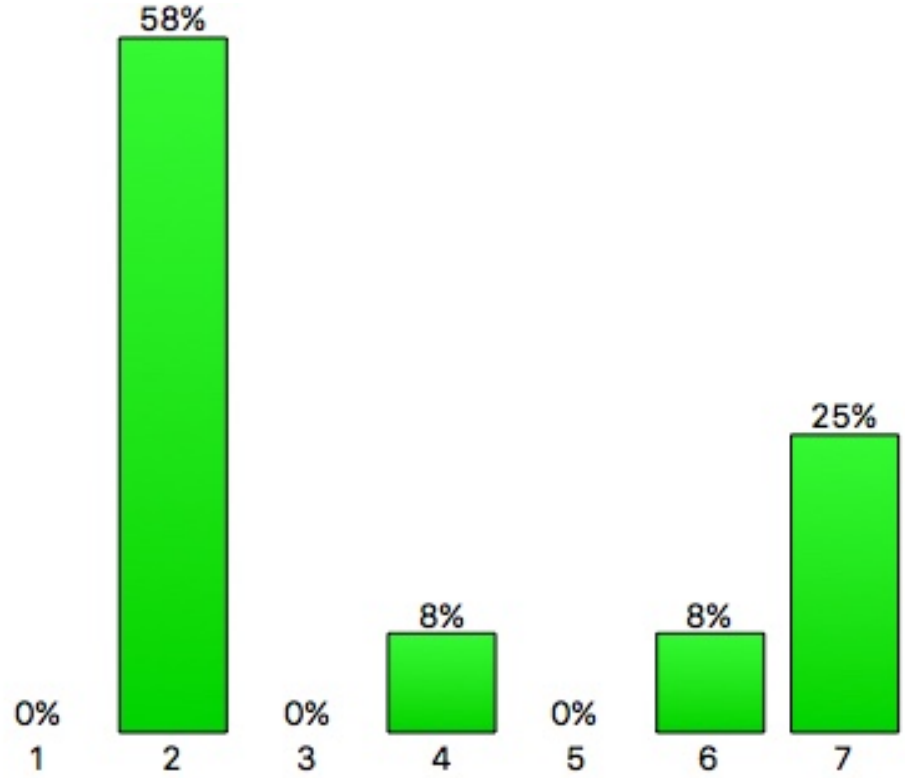


15. I want to narrow this question down to "*What* do students try to avoid by NOT going into STEM education?" to make it as specific as possible:

16. And this is out second stop.

Please, use your clicker again to select an answer!

And feel free to share your thoughts.



And again, we have a distribution, again – no unanimous answer.

17. I want to present my answer gradually.

First, we know that professionals in the same professional area usually have something in common.

If you go into sport and want to become an athlete, you have to be strong.

If you go into arts – you have to be able to express your feelings to others.

What tools do you use depends on your choice: your voice, of gestures, paint, or clay.

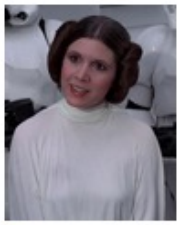
NON-STEM

.....

SPORT

ART

Have in common:



Have in common:

1. Physically strong

2. Enduring

...

1. An ability to express emotions to other people via ...

2. ...

18. What do all people *willingly* entering STEM education have in common?

STEM

Now we can ask

What do all people *willingly* entering STEM education have in common?

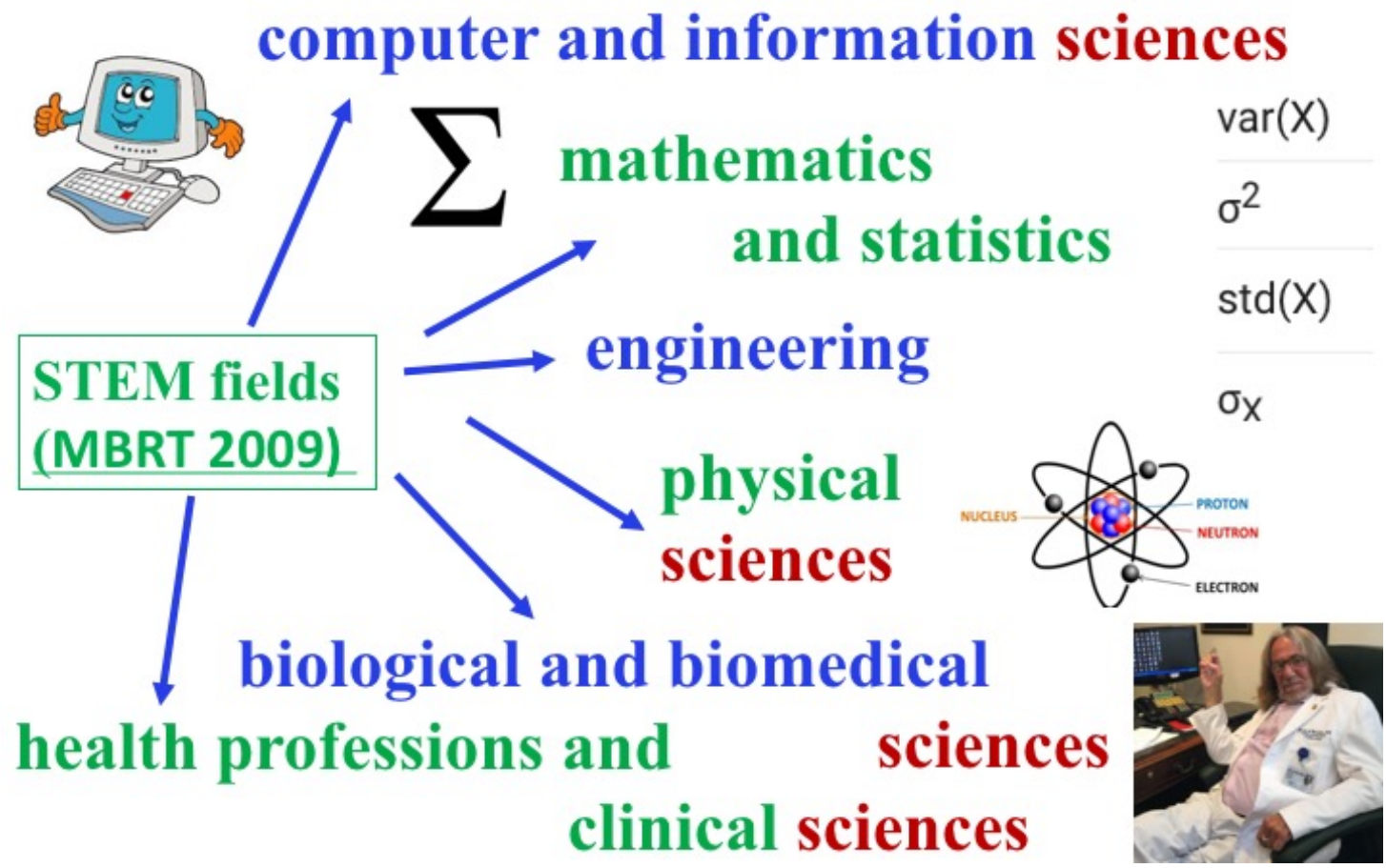
19. "Willingly" is an important word.

We cannot force students into taking STEM courses, like Russia and China do.

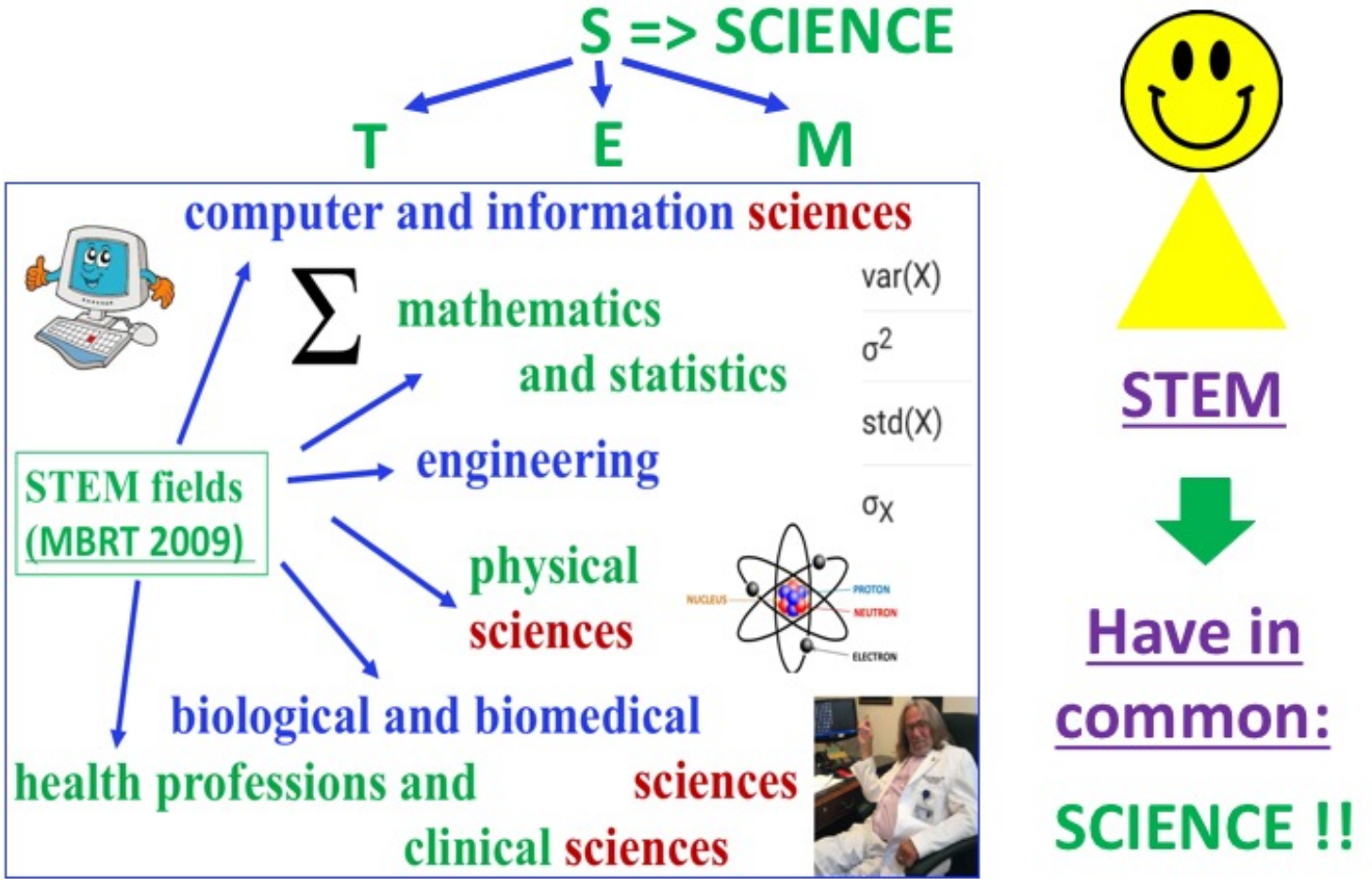
We want to help students *want* to study STEM.

20. If we know what general feature do *all* STEM people share, we can use it to attract people into STEM.

21. The clue is in the definition of STEM. STEM fields include various types of sciences.



22. Science *is* the common denominator for all STEM–related fields. Among four letters S T E M, letter S represents the most important part of it.



23. Now we can answer this question. "What do students try to avoid by NOT going into STEM education?" They try to avoid doing science.

24. "*Why* DON'T students go into STEM education?" => They don't want to do SCIENCE!

25. But, "*Why* DON'T students want to do SCIENCE!

Why **DON'T students want to do SCIENCE?**

26. Well, this out third stop.

Why **DON'T students want to do SCIENCE!?**

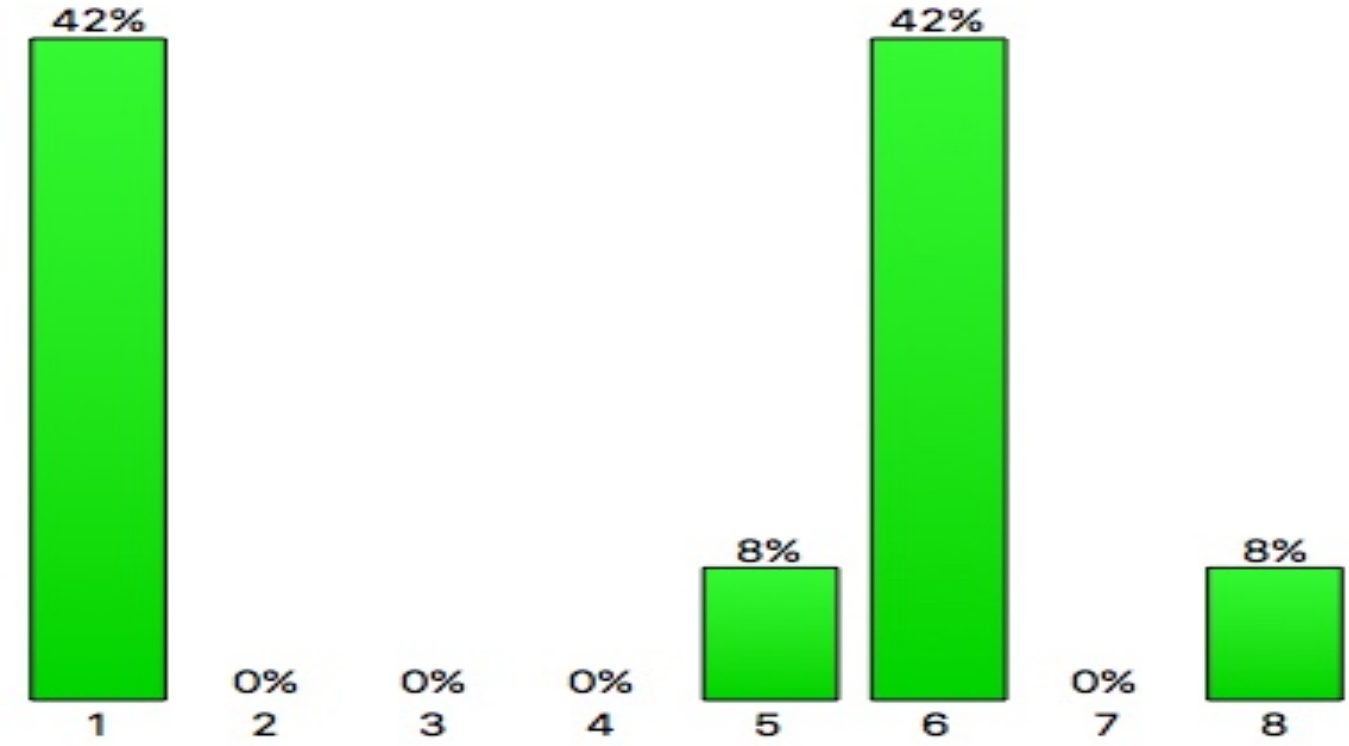
STOP3: => valbu@bu.edu

Please, use your clicker to select an answer!

1. It is boring. **GoMars.xyz/stop3.htm**
2. It needs a lot of mathematics.
3. It requires a lot of money.
4. Not sure.
5. It requires team work.
6. It is too difficult.
7. None of the above.

The question again – do we have a distribution?

Yes!



27. My answer is – because they are scared.

Because they are afraid to get low grades and fail.

28. I am not alone in this assessment.

There is no solid statistical data on the matter, but people write about it.

This piece is about college students. We really just need the title.

Why science majors change their minds? It's just so darn hard.

A study of *college* students

https://www.bloomberg.com/view/articles/2013-07-17/why-american-students-don-t-major-in-science

Why Science Majors Change Their Minds (It's Just So Darn Hard)

By CHRISTOPHER DREW NOV. 4, 2011

Studies have found that roughly 40 percent of students planning engineering and science majors end up switching to other subjects or failing to get any degree. That increases to as much as 60 percent when pre-medical students, who typically have the strongest SAT scores and high school science preparation, are included, according to new data from the University of California at Los Angeles. That is twice the combined attrition rate of all other majors.

https://www.bloomberg.com/view/articles/2013-07-17/why-american-students-don-t-major-in-science

29. There is another one - also about college students, but makes some inferences about schools. And the general conclusion is again: "Science is too hard"

http://www.nytimes.com/2011/11/06/education/edlife/why-science-majors-change-their-mind-its-just-so-darn-hard.html

If the conclusions generalize, the lessons are clear. College teachers aren't to blame. American students aren't uninterested in science, nor are they ignorant of the professional opportunities that a degree in this field could bring. Many of them would like to major in science and plan to do so. But when they are disappointed by their own performance, they switch. The impediment is a lack of high school preparation.

"Science is too hard"

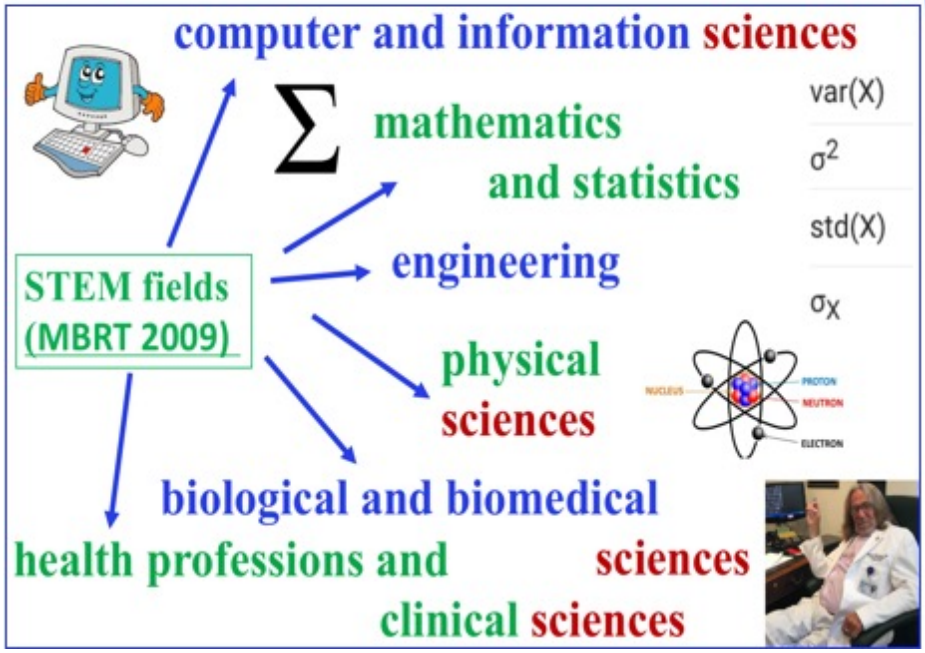
http://www.nytimes.com/2011/11/06/education/edlife/why-science-majors-change-their-mind-its-just-so-darn-hard.html

30. But, why is science so scary? What does make it so hard? The answer depends on our definition of "science"?

Why is science so scary? The answer *depends* on what do we call a "science".

S => SCIENCE

STEM



T

E

M

Have in common:

SCIENCE !!

? ? ?

What is it?

31. This is our fourth stop.

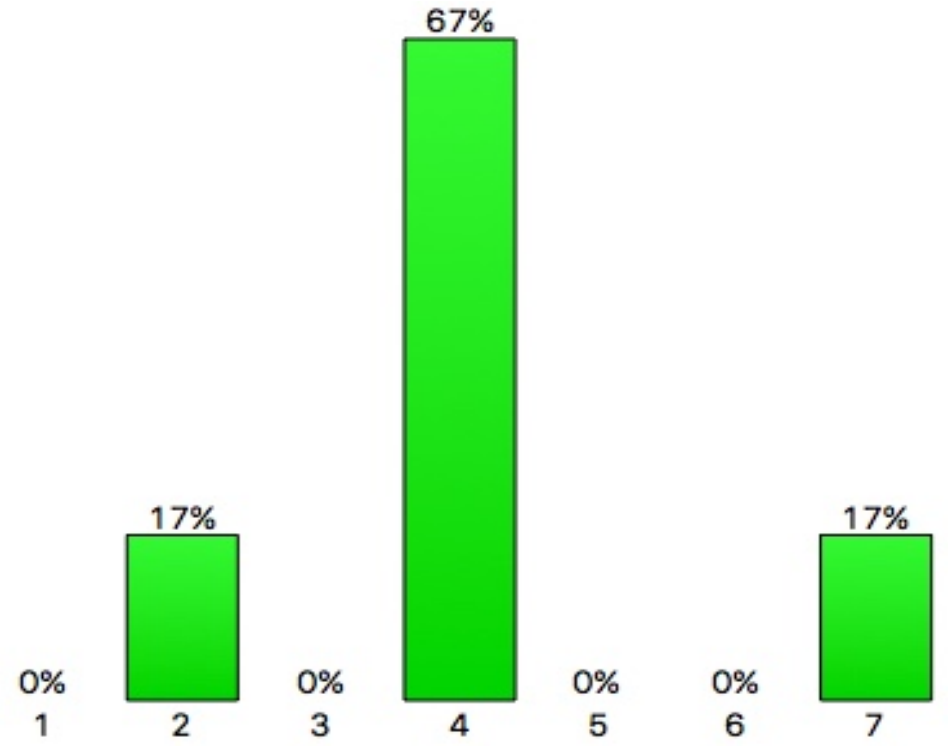
What is "Science?"

Please, use your clicker to select an answer!

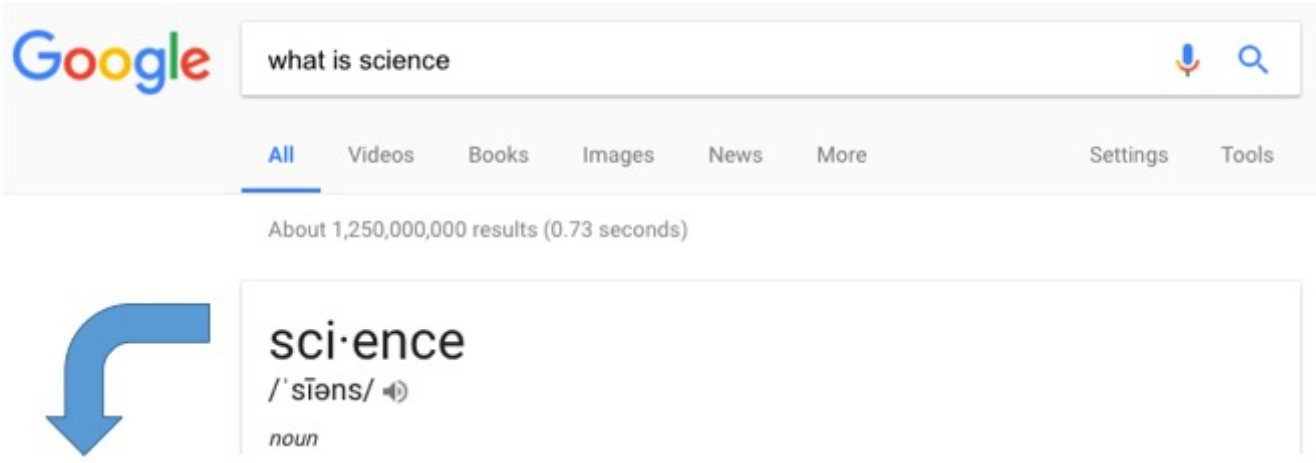
1. No one really knows.
2. Thinking about the universe.
3. Developing new devices.
4. It is hard to give an exact definition to science.
5. A fairy tale for kids.
6. A hoax created by top one percent.
7. None of the above.

GoMars.xyz/stop4.htm

STOP4: => valbu@bu.edu



32. Good thing about living in 2017, we don't have to know things. We can just Google! If you Google "what is science" you'll get about 1,250,000,000 results in less than a second. This is the top Google search result. You can also find similar statements in many textbooks. But, what does it really mean?



Top Google Result: science is "the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment."

33. In simple words, according to this definition: science is a human activity (not for animals) – to be practical; requires doing something like watching or actually acting,

requires doing it on a regular basis, like every day (to be systematic);

and also, requires some thinking (to be intellectual). Can we use this definition?

Top Google Result: science is "the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment."

Not for animals (practical); ← Meaning: "Science" is

Requires *doing* something (watching, acting = observation, experiment);

Requires doing it *Regularly*, e.g. every day (= systematic);

And involves *thinking* (= intellectual).

Useful ?

34. Not really.

This definition helps to separate working people from lazy people.

However, this definition does not allow to separate science from a religion, or art, or sport.

Top Google Result: science is "the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment."

Do something every day and think about it! ← Meaning

1. Separates working people from lazy people.
2. Does *not* separate science from a religion, or art, or sport.

I (human) do something and think every day!

35. There is another approach to a definition of science: practical. This is what we know about science.

The mission of science is making predictions. The functioning of science is based on searching for patterns.

Pattern description and pattern recognition is based on data analysis. In similar circumstances, we expect to observe similar patterns. Those circumstances we call conditions, and they represent a part of the pattern.

Definitely Know About Science:

The *mission* of science ➡ **Making *predictions***

The *functioning* of science ➡ **Searching for *patterns***

***Pattern* description/ recognition** ➡ **Via *data* analysis**

The Foundational Rule: In similar circumstances (a.k.a. *conditions*), we expect to observe similar patterns.

36. Based on this knowledge, the best definition of science is not a descriptive, like offered in many textbooks, but a prescriptive, or operational. The key elements of science are data, patterns, and predictions.

The best definition of science

(not descriptive, but prescriptive/operational)

"A science is an internally consistent body of knowledge based on the scrupulous and logical analysis of a vast amount of data, presented via description of various patterns (including the conditions for being observed), with the mission of predicting future events".

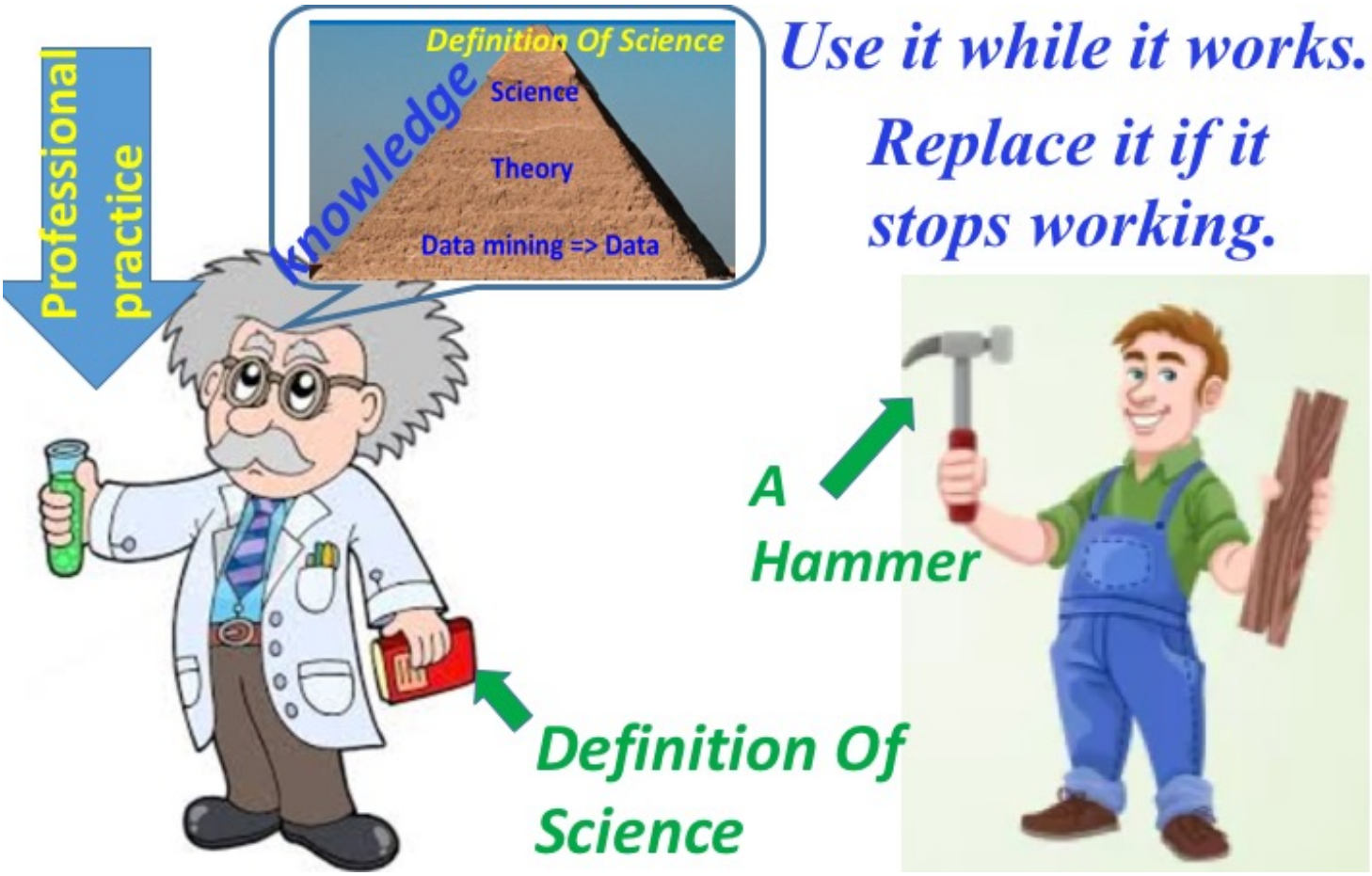
Science = (data + patterns) * predictions

Patterns = regularities + conditions

37. Of course, you don't have to use my definition of science.

This knowledge, like any knowledge, is just a tool for organizing our professional practice.

It is like a hammer for a carpenter: use it while it works, replace it with something better if it stops working.



By the way, in terms of teaching science we need to start from the most clear and practical definition of it, so students could become confident in their ability to do science, and then gradually move to the higher level understanding of the nature of science.

38. Which brings us to the last stop.

For this stop we will need a volunteer, a scientist, who will solve a problem by thinking out loud.

This is a very old problem. If anyone knows the solution, please don't say a word!

One person should start thinking out loud, no need to come over, just start saying every thought every word coming to mind.

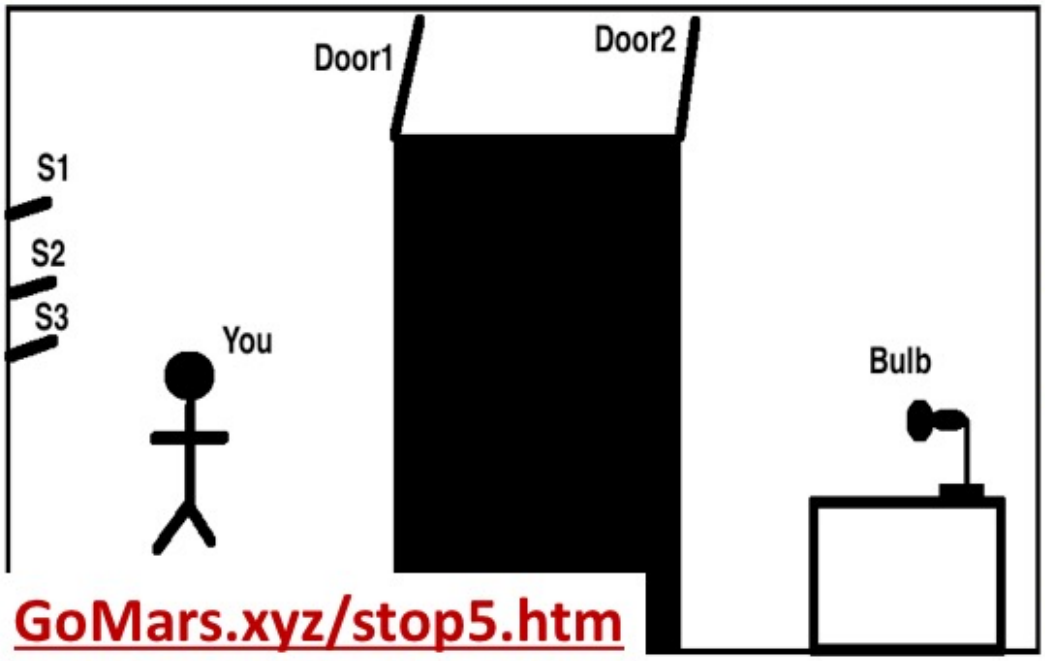
Also, you can ask me any questions.

I will be keeping the track of the problem-solving process.

If you were my students I could entice you by offering an extra credit. For you I can offer only a free visit to your class.

Science = (data + patterns) * predictions

Patterns = regularities + conditions



We need a volunteer for thinking out loud!

http://wiki.c2.com/?ThinkingOutLoud

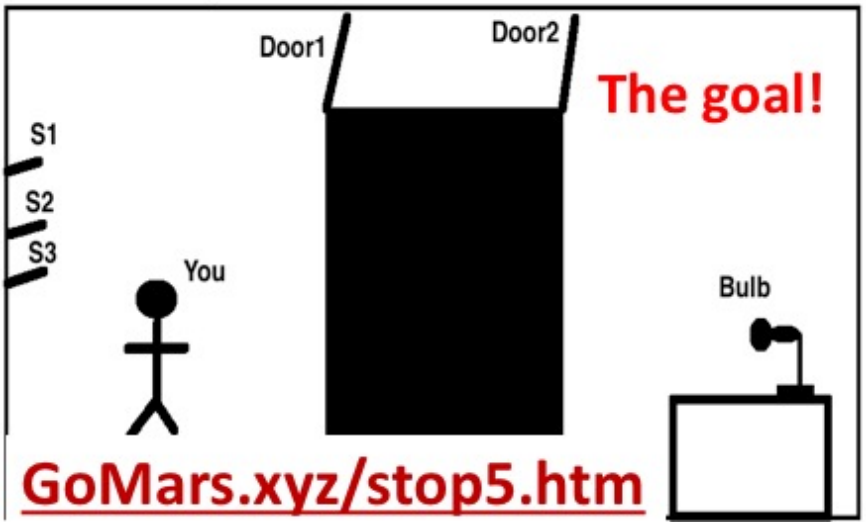
39. This is the problem we need to solve.

I love this problem.

The first time when I had to solve it, I did it exactly same way – by thinking out loud.

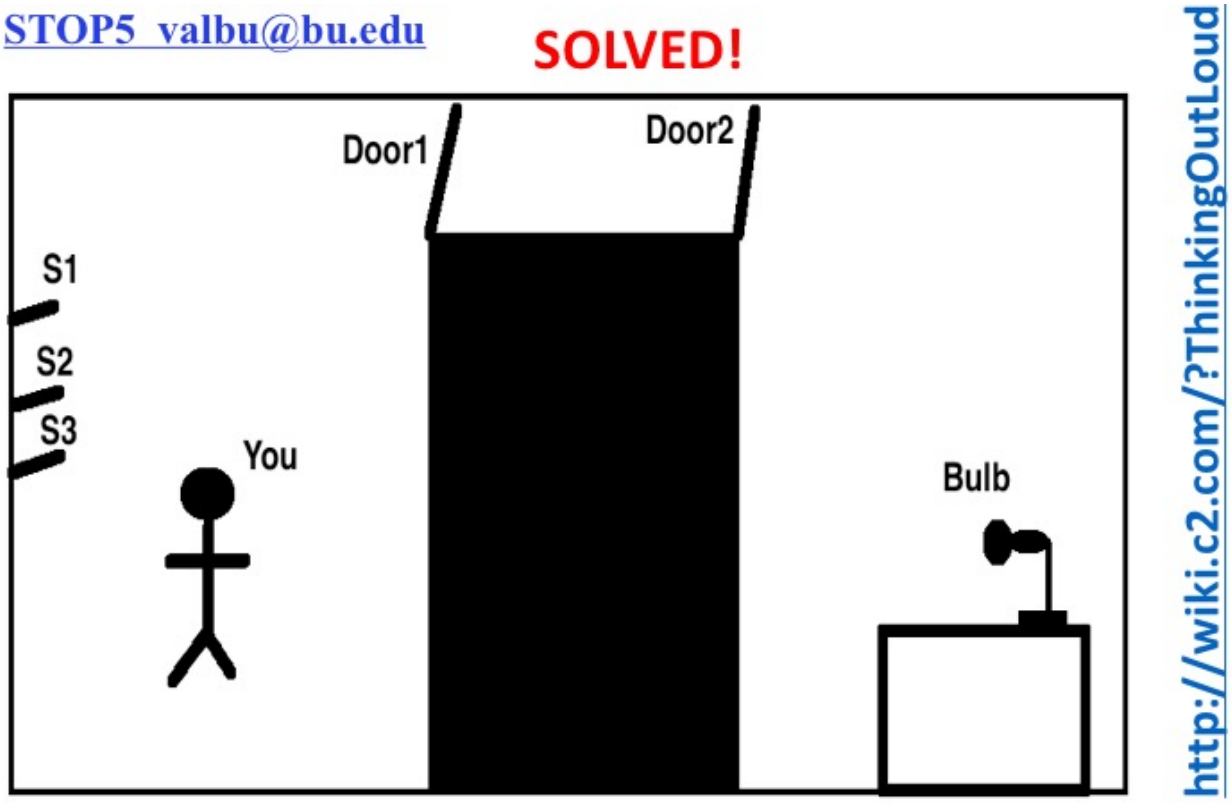
But it was about 20 years ago.

The General Electric (it just moved its headquarters in Boston!) decided to hire several more electricians, and you are one of the applicants. You have already successfully passed several interviews, and now you are having the last one. The hiring person leads you in the room, gives you this picture and says this. "When you enter the first room you will see three switches; switch # 1, switch # 2, and switch # 3. They all are absolutely identical; you will never be able to find out any difference between them. There is also another room, which is behind a five-yard hallway with two doors. In that room, on a table, there is a table lamp with a regular incandescent bulb in it. One, but only one of the three switches in the first room is connected to the table lamp and turns the bulb on. There are no any windows in any of the rooms, the walls are thick, the doors are closed, so, when you enter the second room you will have no way to come back in the first room, or to reach, or to see any of the switches. After entering the first room you can stay in it as long as you need, and you can turn the switches on and off in any way you like. Then, when you are ready, you have to go to the second room. I will be waiting there for you. You will have to tell me which switch turns the bulb on."



STOP5 valbu@bu.edu

40. Done! Do not touch switch one. Turn on switch 2 and wait until the bulb might get hot. Turn off switch 2, turn on switch 3 and run into the next room. If the bulb is on => switch 3. If the bulb is off – touch it: if it is hot => switch 2. Otherwise => switch 1!

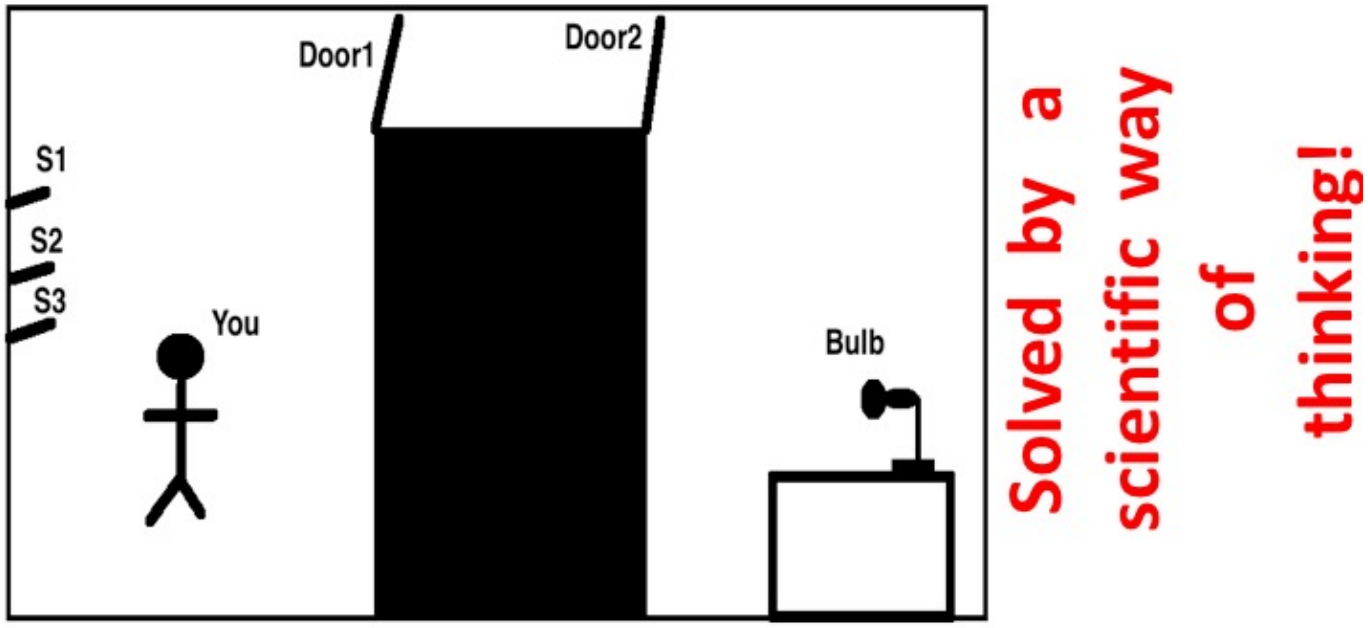


http://wiki.c2.com/?ThinkingOutLoud

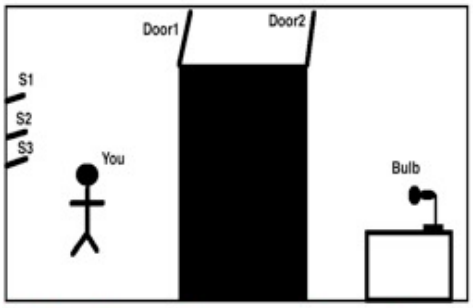
41. How did we solve this problem? We used a specific way of thinking! The structure of the reasoning process, the rules of engagement, thinking patterns replicate the reasoning we use in every scientific investigation. To solve this problem, we used a *scientific way of thinking!*

Science = (data + patterns) * predictions

Patterns = regularities + conditions



42. Let's go over the structure of the scientific way of thinking one more time. At first, we see many different things, we call them objects, we use nouns to name those objects, we use our index finger to point at those objects. There might be many objects to point at. We have to make a decision, which objects are important for this situation? That is the first – the simplest classification we need to make.



Solved! ***By a specific way of thinking!*** **Scientific!**

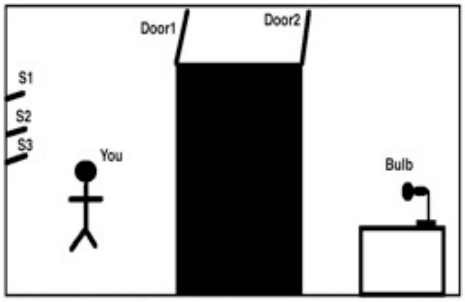
Let's *reflect* on it.

1. Seeing (or imagining) *things* = objects.

Naming (and classifying) *important* objects.

Walls, doors, switches, a table, a table lamp or a bulb, a person, another person (a guy from GE), wires connecting the bulb and one of the switches, doorknobs on the doors, glasses, hat and a tie.

43. Then we need to say something *about* those objects. First, about some internal properties. A property of a switch is to be on or off. The bulb can be dark or bright. The bulb also can be cheap or expensive; manufactured in China or in the US. It can be hot or cold. We can list many properties. And again, we need a classification: in this case - very simple: What's important and what's not.



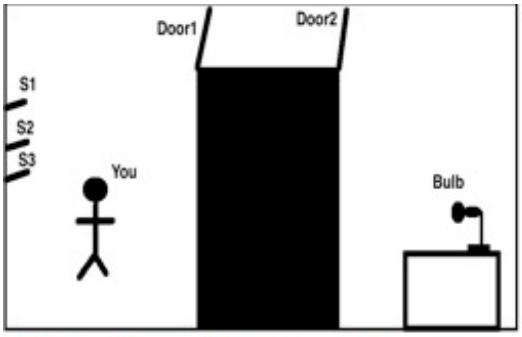
Solved! ***By a specific way of thinking!*** **Scientific!**

Let's *reflect* on it.

2. Listing *important* properties of important objects.

A switch is to be on or off. A guy can be in a room, or on a move. The bulb can be on or off. The bulb can be cheap or very expensive. The bulb can be manufactured in china or in the US. The bulb can be hot or cold.

44. The next step is to talk about changes – actual or possible. We need to say something about evolution of the objects and their properties. Basically, we answer a question – what is or might be happening?



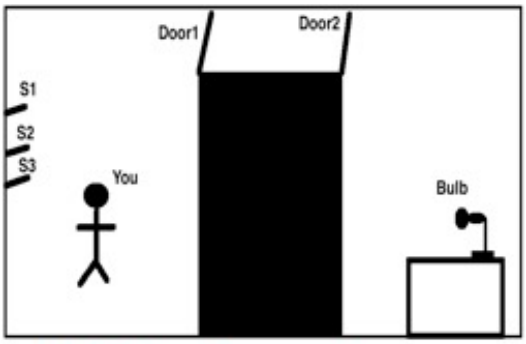
Solved! *By a specific way of thinking!* Scientific!

Let's *reflect* on it.

3. Seeing *changes* = processes ("what is happening?"). Naming *important* processes.

The bulb can be glowing or being dark; worming up or being cold. The guy can be resting or moving, flipping switches or giving up.

45. Each process has its own properties. Motion can be fast or slow. Glowing can be dim or bright.



Solved! *By a specific way of thinking!* Scientific!

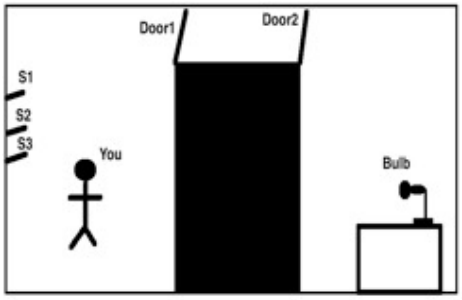
Let's *reflect* on it.

4. Listing *important* properties of important processes.

Motion can be fast or slow. Glowing can be dim or bright. Worming can be fast or slow. Thinking can be painful or painless.

46. To describe properties of objects and processes we use parameters: Such as temperature, speed, brightness.

And for each parameter we can assign some values, like miles per hour, Degrees, Lumens. Well, since this problem was simple, we didn't have to calculate anything, so we did not use any specific values.



Solved! *By a specific way of thinking!* Scientific!

Let's *reflect* on it.

5. Describing various properties using various parameters. Describing various states and changes using values various parameters.

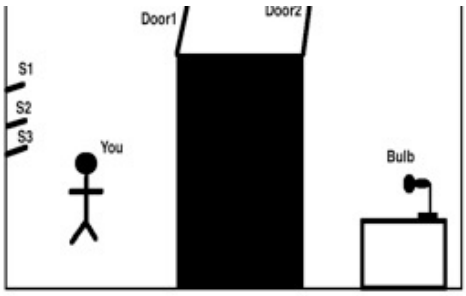
To describe how fast something is moving we use speed. To characterize speed we use mi/h.

Hotness => Temperature => Degrees.

Shininess => Brightness => Lumens

47. However, to solve even this simple problem, we had to use our knowledge about specific patterns. We used a correlation between a switch being off, and a bulb connected to the switch being off. We used a correlation between a switch being on, and a bulb connected to the switch being on. Etc.

By the way, in science a stable, reliable patter has a name. We call it a law!



Solved! *By a specific way of thinking!* Scientific!

Let's *reflect* on it.

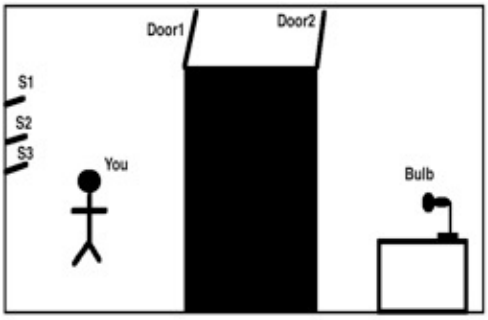
6. Stating important patterns (i.e. well established connections between important entities – a.k.a. laws).

A switch is on/off ⇔ a bulb is on/off.

An incandescent bulb is on ⇔ an incandescent bulb is hot.

48. And finally, using all our knowledge, we need to establish the correct procedure for achieving the goal.

If we didn't know some of the important properties or patterns, we would have to discover them first, and then to solve the problem.



Solved! ***By a specific way of thinking!*** **Scientific!**

Let's *reflect* on it.

7. Using important patterns to establish the correct sequence of events (an algorithm, a solution).

Thinking/Giving up

Moving ahead/Remaining still

49. This is how science works. Any science. When we need to solve a scientific problem, we have to use a scientific way of thinking.

A *scientific* way of thinking (the pinnacle of science!)

1. Seeing (or imagining) *things* = objects. Naming *important* objects.
2. Listing *important* properties of important objects.
3. Seeing *changes* = processes. Naming *important* processes.
4. Listing *important* properties of important processes.
5. Describing various properties using various parameters. Describing various states and changes using values various parameters.
6. Stating important patterns (i.e. well established connections between important entities – a.k.a. laws).
7. Using important patterns to establish the correct sequence of events (an algorithm, a solution).

GoMars.xyz/general_algorithm.htm; GoMars.xyz/sp.htm

GoMars.xyz/general_algorithm.htm; GoMars.xyz/sp.htm

50. Teaching science without teaching a scientific way of thinking

THAT what makes it so hard that students give it up.

When teachers do *not* use a scientific way of thinking.

51. The ultimate goal of ANY STEM subject is developing a scientific way of thinking.

Specific subject-related knowledge is a "collateral gain" of a science course.

We will never be able to attract students into STEM if we treat science courses as a basket of random facts.

We have to treat all science courses as a way for developing a scientific way of thinking.

2016 Massachusetts Science and Technology/Engineering Curriculum Framework


April 2016

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The goal of EVERY middle school and high school science subject *should be* the development of

A *scientific* way of thinking

1. Seeing (or imagining) *things* = objects. Naming *important* objects.
2. Listing *important* properties of important objects.
3. Seeing *changes* = processes. Naming *important* processes.
4. Listing *important* properties of important processes.
5. Describing various properties using various parameters. Describing various states and changes using values various parameters.
6. Stating important patterns (i.e. well established connections between important entities – a.k.a. laws).
7. Using important patterns to establish the correct sequence of events (an algorithm, a solution).

52. Now I want to make my last "stop" in my presentation. This time is not for a question, or a problem to solve. This time I want to make a statement.

This is the summit, the peak, the apogee, the pinnacle of this presentation.

"STOP"6

STOP1, 2,3 = a "discussion" => to collect (share and compare) individual views.

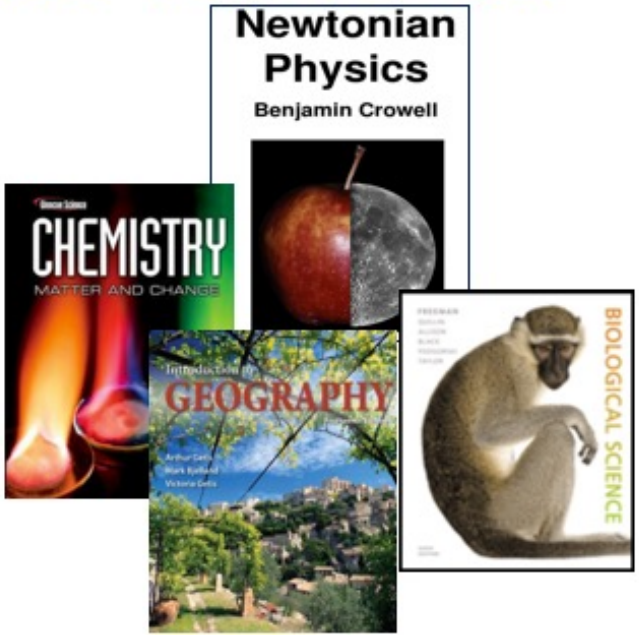
STOP4 = a "discussion" => to establish a common understanding (a definition).

STOP5 = discussion => to reflect on a collaborative problem solving experience

"STOP"6 => the central *statement* of the presentation (has two parts).

53. Among all school subjects, physics is the best suited for the development of a scientific way of thinking – *if* it is properly taught.

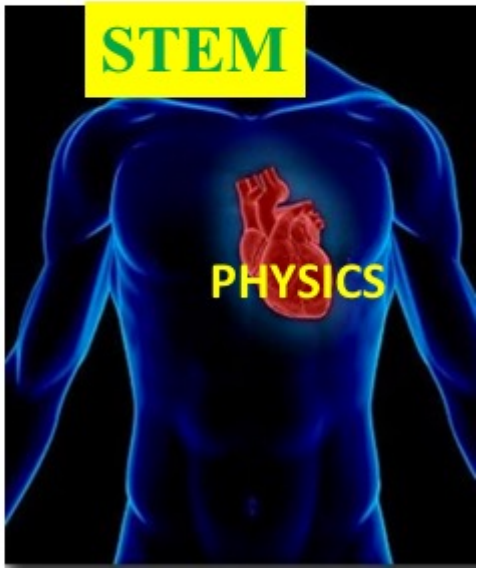
I. Among *all* school subjects, *physics* is the *best* suited for the development of *the scientific way of thinking* – *if* it is properly taught.



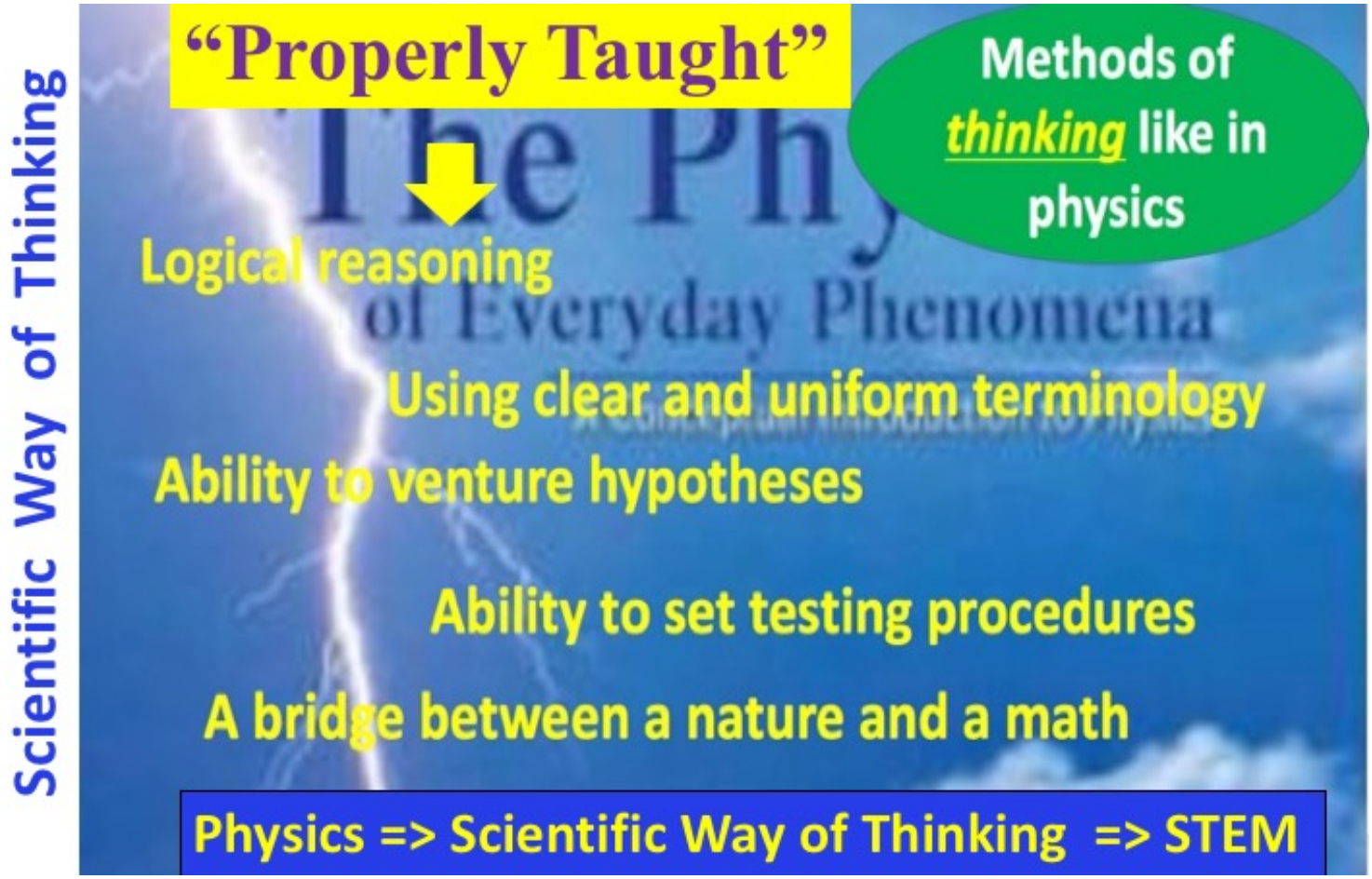
54. Hence. Among all school subjects, physics (*if* it is properly taught) is the best suited for the *attracting* students into STEM education.

II. Hence, among *all* school subjects, *physics* (*if* it is properly taught) is the *best* suited for *attracting students into STEM education.*

Because the essence of STEM education is developing the scientific way of thinking.

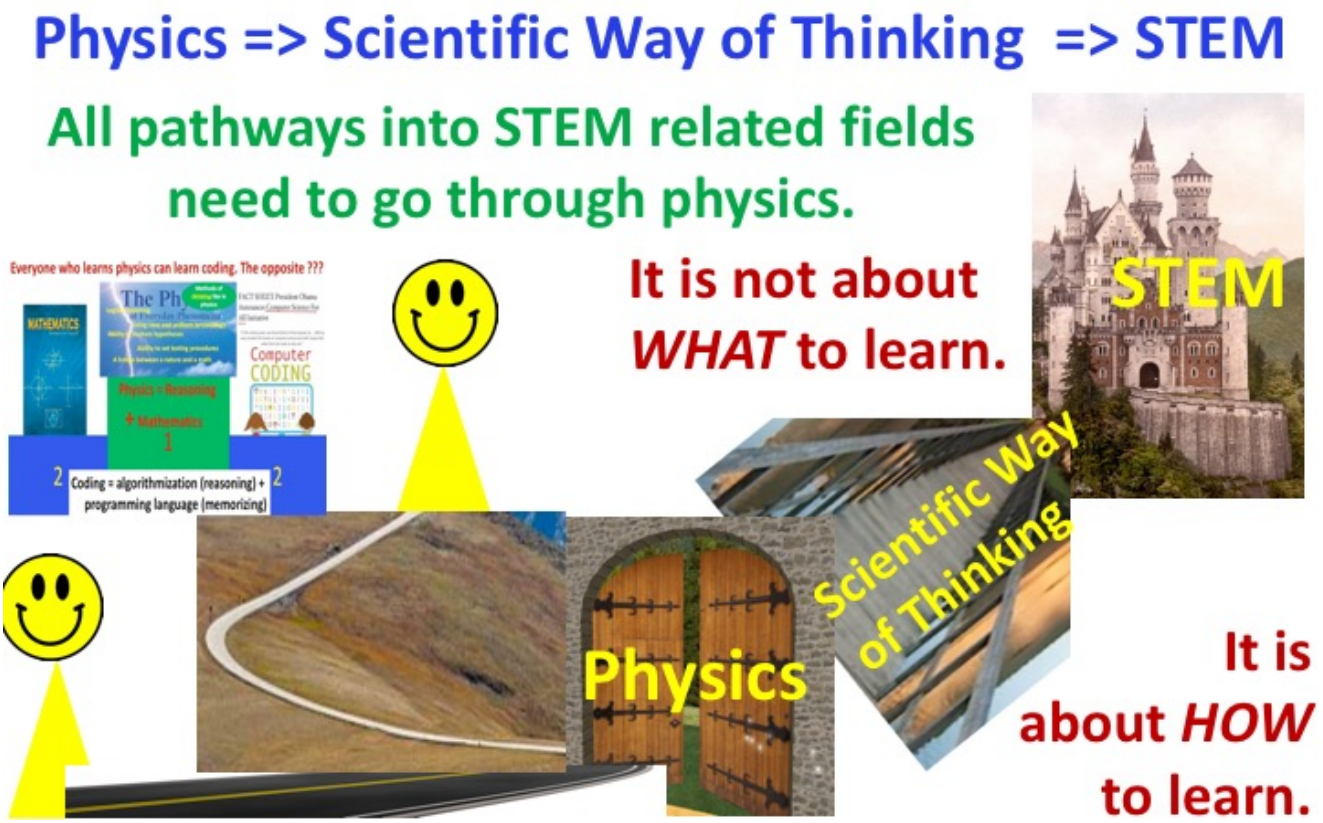


55. "Properly Taught" means – using the scientific way of thinking.

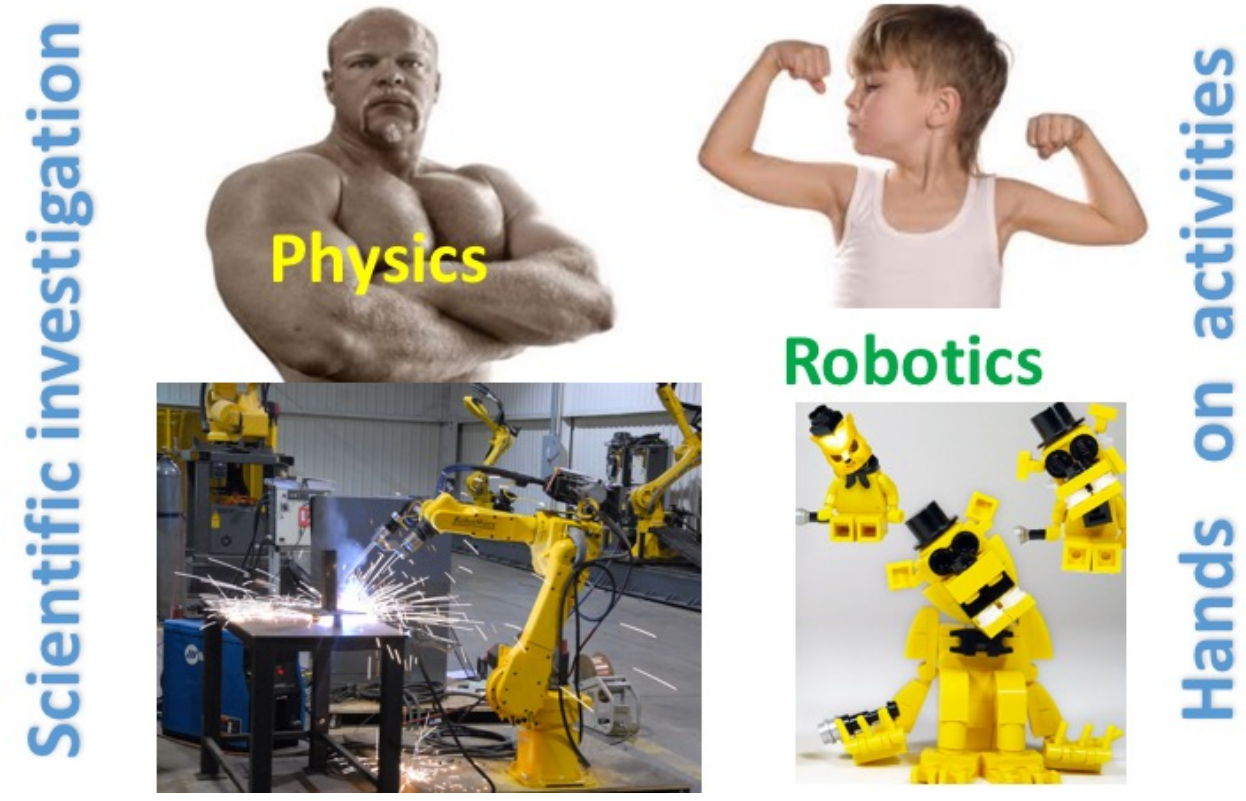


56. All pathways into STEM-related fields need to go through physics. The reason for that is not related to *what* people learn, but HOW! It is not about study rocks, or wires, etc. It is about *learning to think scientifically* about rocks, or wires, etc.

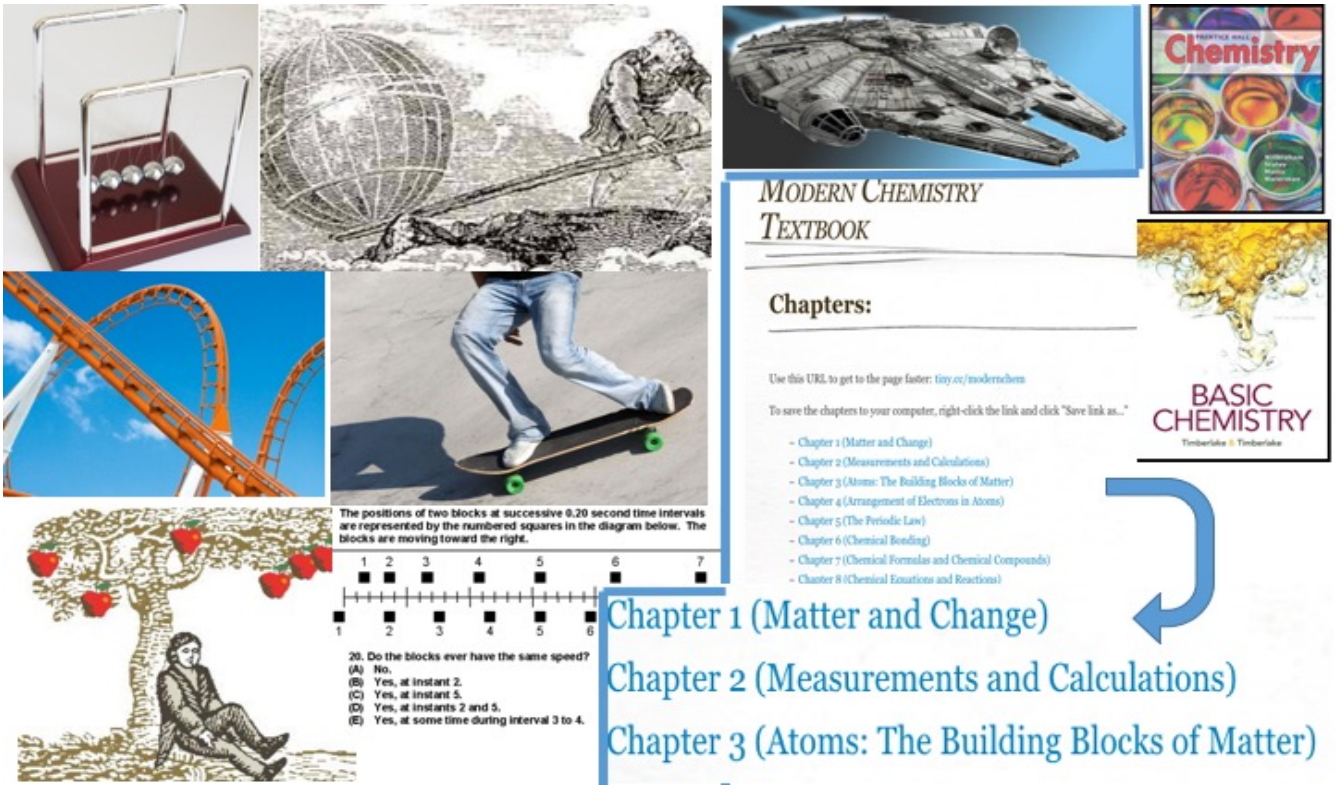
Well, I could have stopped just here, but I still have to say something "bad" about all other subjects, haven't I (this is a joke – of course)?



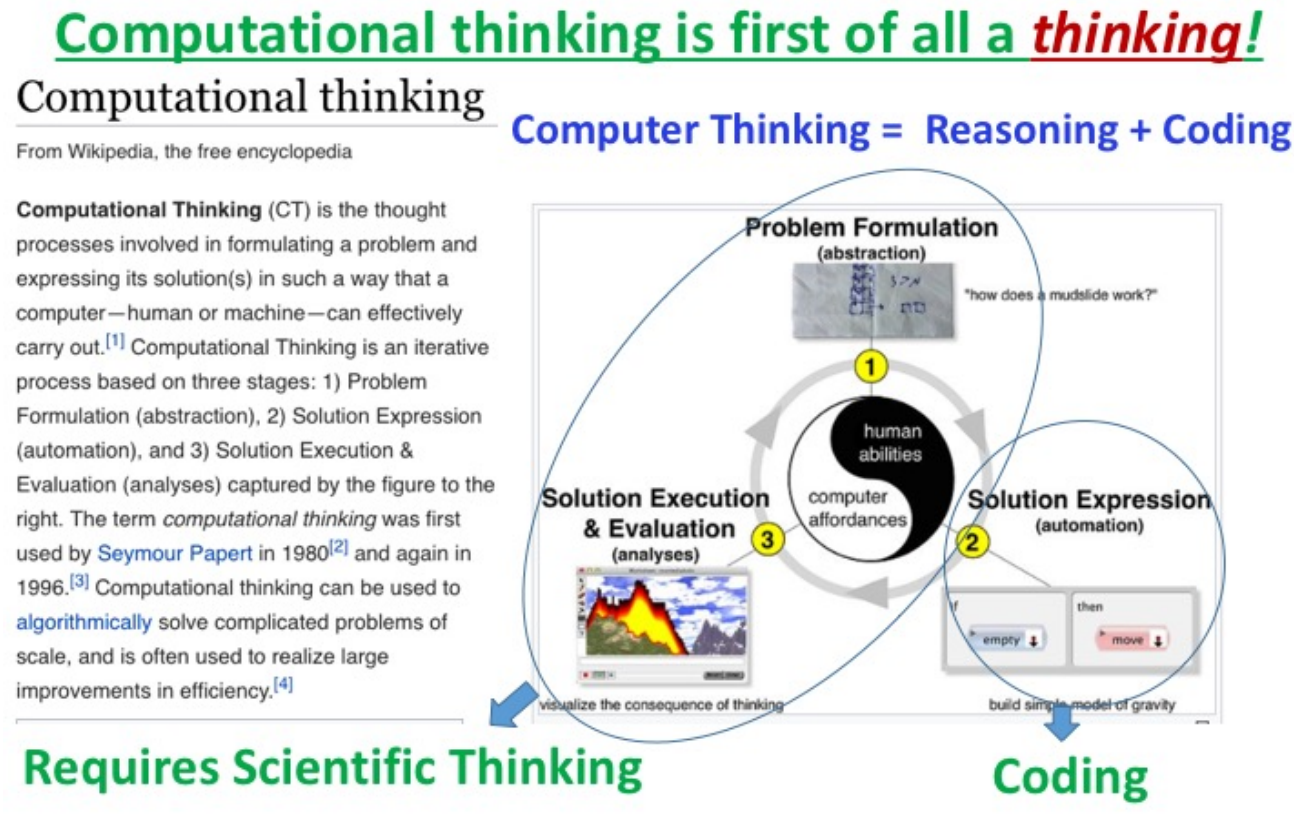
57. The subject which is the closest to physics is Robotics. No doubt, Robotics helps to excite kids about science. However, in terms of developing a scientific way of thinking, Robotics does not provide the same opportunities as physics does. It is more of a hands-on activity, than a scientific investigation. Advance levels of Robotics represent engineering, and require already solid knowledge of physics.



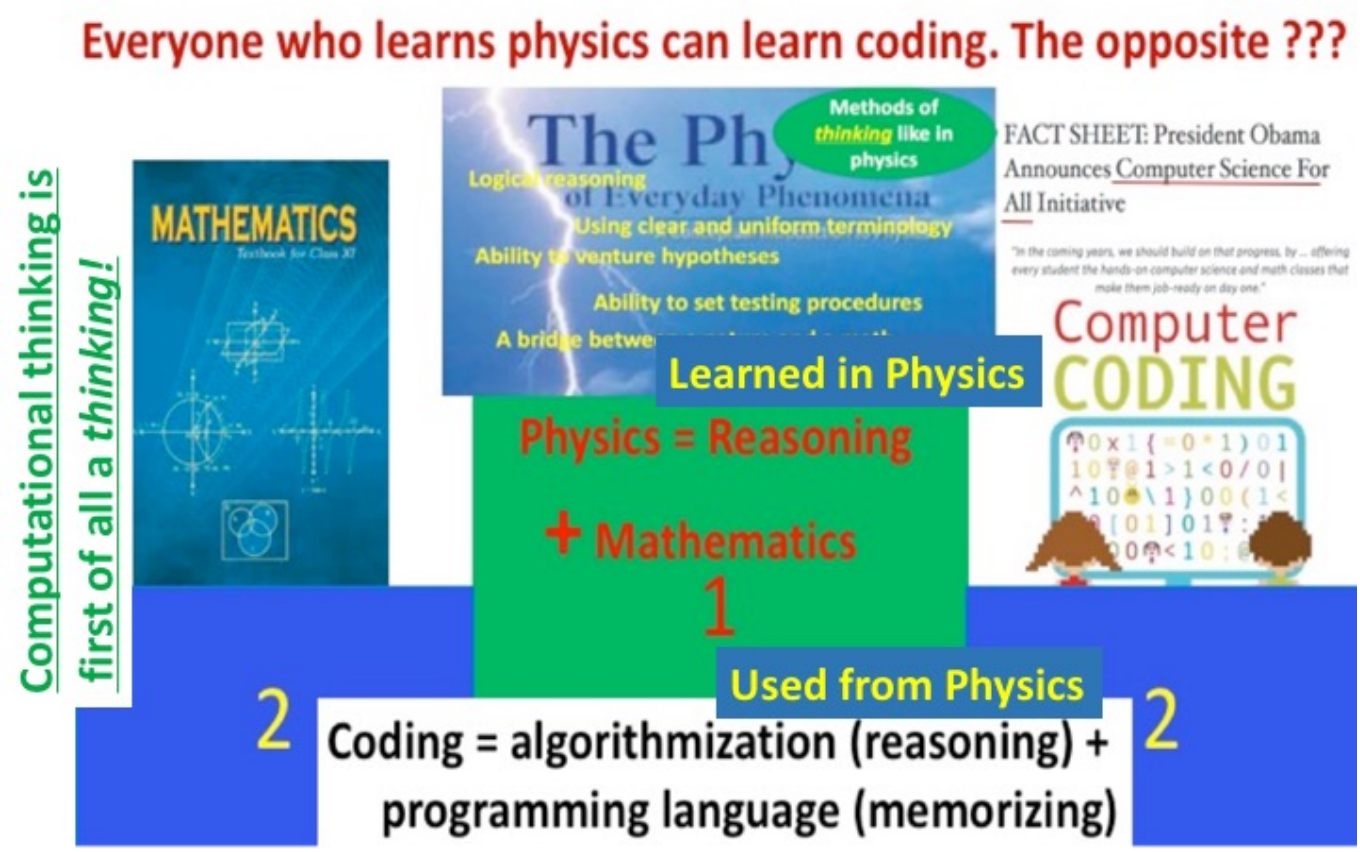
58. When students have the first encounter with physics they deal with objects and process *they already know* – falling rocks, moving cars, etc. Chemistry or biology do not provide enough practical material which students can use as a basis for developing logical reasoning, at least not as much as physics does. Almost every chemistry course starts from talking about mass, density, energy – which is physics; then it talks about atoms and molecules – which are tiny invisible abstract objects connected by forces (which is physics), acting like small balls (again physics).



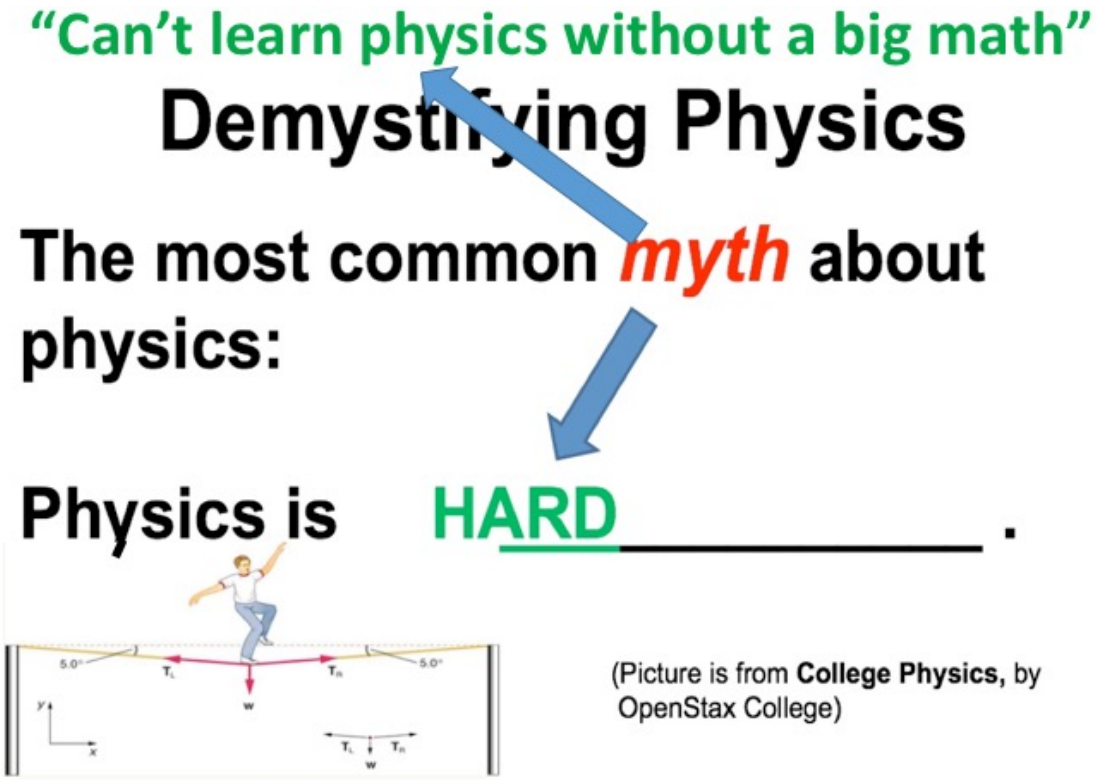
59. Lately, "computer coding" and "computational thinking" have become buzz words and gained significant support from officials and philanthropists. There is nothing wrong with it. But people need to understand that computational thinking is – first of all – a *thinking*. Computational Thinking is a combination of reasoning and coding.



60. Physics is a combination of Reasoning and Mathematics. Physics and computational thinking share "thinking" as the central part. But in physics students deliberately learn a scientific way of thinking. Computational thinking requires already developed reasoning skills. Everyone who learns physics, *automatically* develops the most important part of a "computational thinking" (which is - thinking!), and can easily learn computer coding – *the opposite is just not true.* Now we need to talk about math.



61. There is a common misconception that to learn physics one has to be good at math. That is a myth. There are much more difficult things to learn. For example, for most people to learn how to solve a problem about walking a rope (http://teachology.xyz/general_algorithm.htm) would be much easier and faster than to learn how to actually walk a rope.



62. That perception, that myth about math, that to do physics you have to be good at math, scares many students away from taking physics. If we look around and everyone tells us "Physics is hard, it's only for chosen ones, you have to know a lot of math" we are not going to even try it, because most people don't try if they expect to fail.

Because students are afraid to fail science.

Will you study physics is you hear this every day "Physics is hard, it is only for chosen ones, you have to know a lot of math" ?

63. On the contrary, taking physics will help students get better at math. What do students hate the most in math courses? Word problems. But to solve word problem we have to use the exactly same scientific way of thinking we used to solve the problem about a bulb.

Suggestions:

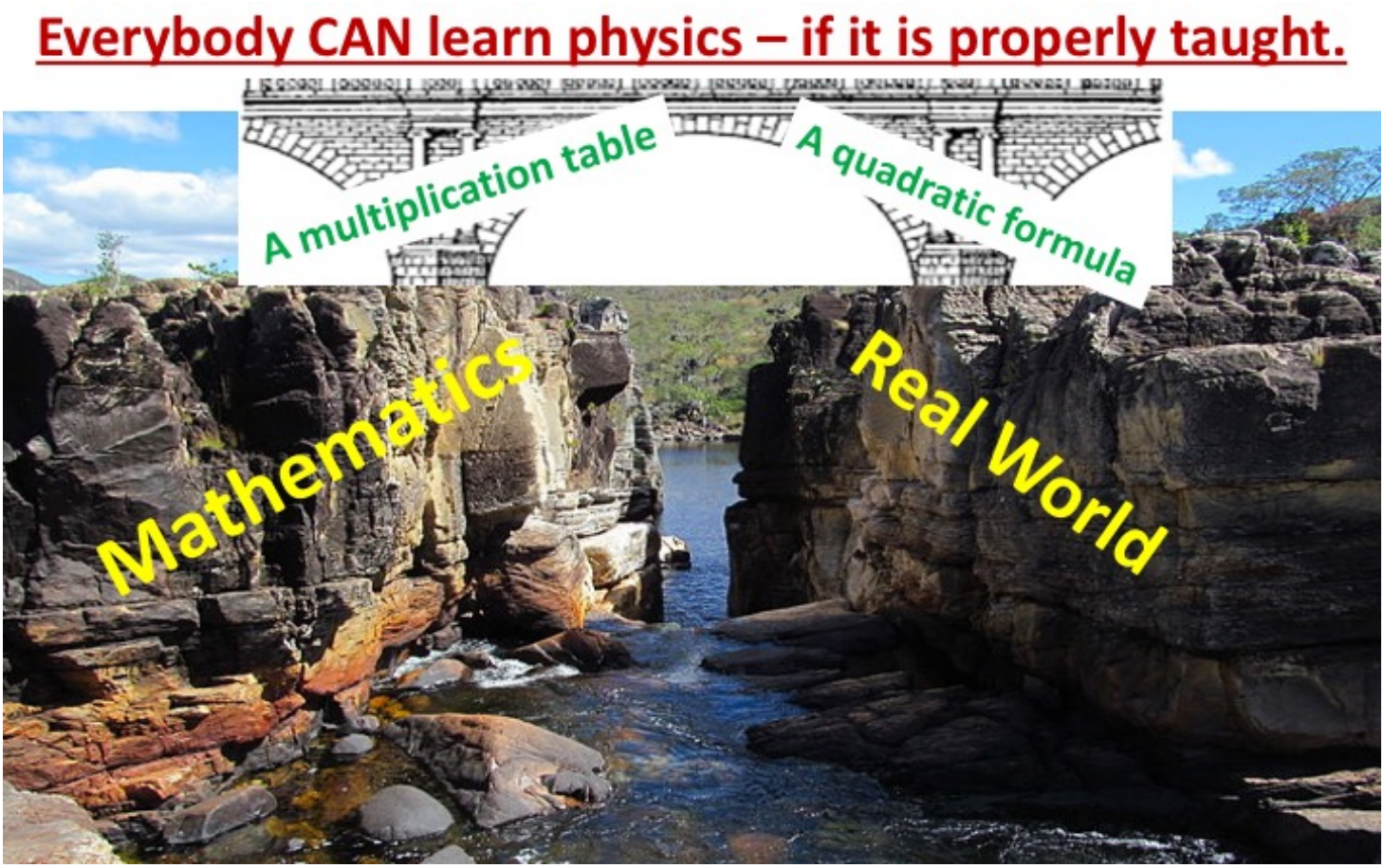
1. Read the problem entirely. Get a feel for the whole problem.
2. List information and the variables you identify. Attach units of measure to the variables (gallons, miles, inches, etc.)
3. Define what answer you need, as well as its units of measure.
4. Work in an organized manner. ...
5. Look for the "key" words (above)

Solving Math Word Problems:: explanation and exercis
www.studygs.net/mathproblems.htm

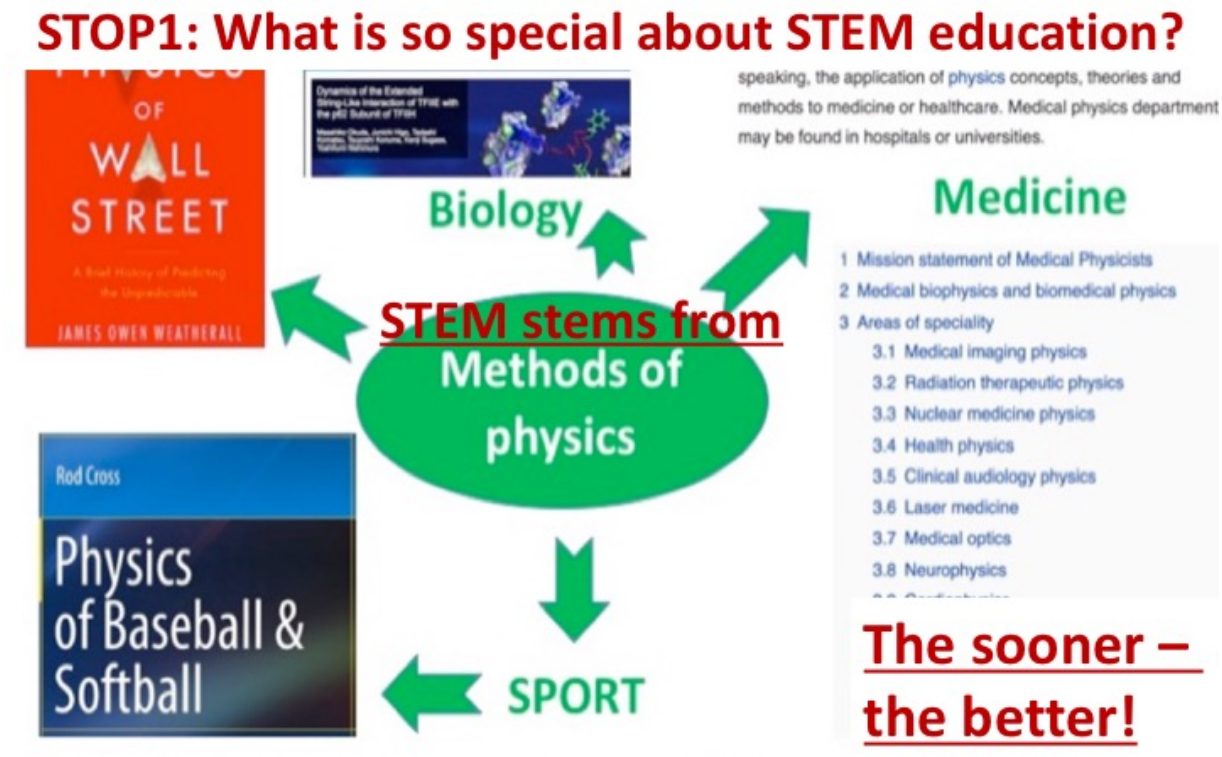
Grandmother is bringing an apple pie to Thanksgiving dinner. She needs to buy 9 apples, 2 bags of sugar, 3 bags of flour, and 2 jars of honey. How much money did Grandmother spend at the grocery store?

"Two union workers can dig two yards of a trench in two hours. How many yards of a trench will four union workers dig in four hours?"

64. Physics is uniquely positioned as a bridge between an abstract world of mathematics and a real world of actual phenomena. Everybody CAN learn physics – if it is properly taught. Everyone who knows a multiplication table, and can solve a quadratic equation can *succeed in a physics*.

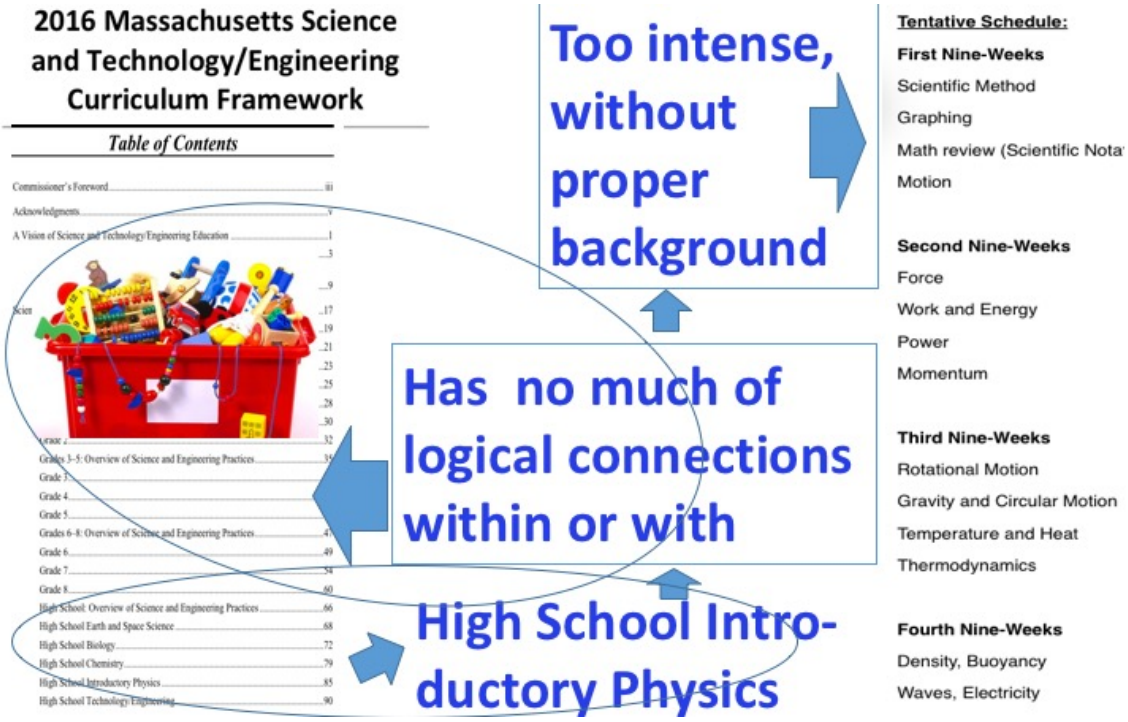


65. Nowadays, learning physics is also important because it has entered many other professional practices including business, medicine, sport. Everyone who considers a career in a STEM-related field, will have to take physics. This is a practical reason why students need physics. Remember the question for STOP1? "What is so special about STEM education?" My answer is: because all STEM courses are based on a scientific way of thinking, which stems from physics.

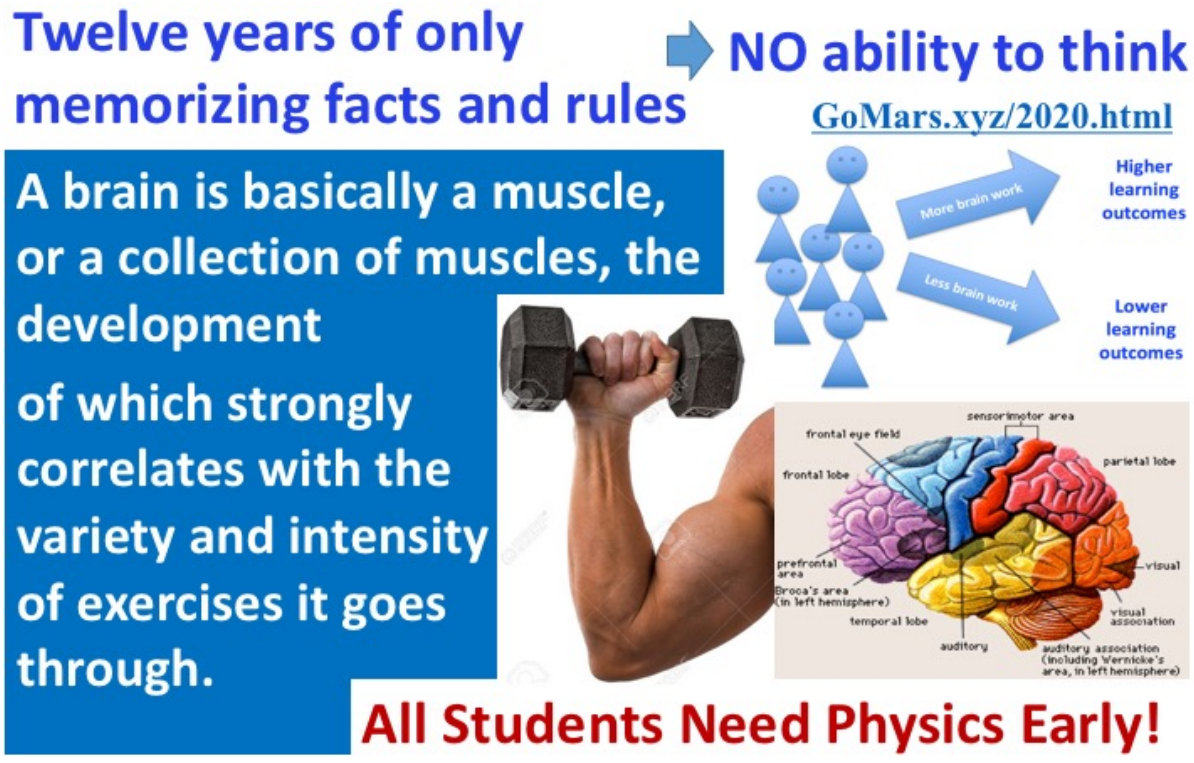


66. The first problem with current way of teaching physics is structural. Starting physics in 11th or even 9th grade is just too late. It demands to much work over a short period of time. Which again is another reason WHY many students avoid physics. <u>The sooner students start taking physics, the more confident they will feel in the future when thinking about going into a STEM related field.</u>

The best approach would be structuring or stretching at least the same amount of the material over a longer period of time, starting physics in the 7th grade.

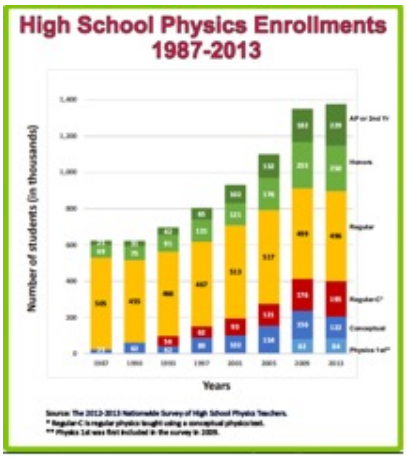


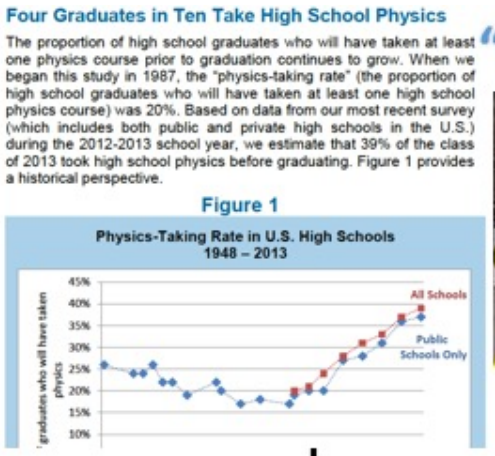
67. But the most important reason for starting physics yearly is related to the process of a brain development. A brain develops in a way similar to the development of regular body muscles. It needs many different exercises. If the only exercise students had been doing for twelve years is squats, they will not be good at push-ups and pull-ups. Similarly, if all students had to do for twelve years was memorizing facts and rules, we cannot expect from them an ability to think. And physics – when properly taught – is the best tool for developing reasoning skills.

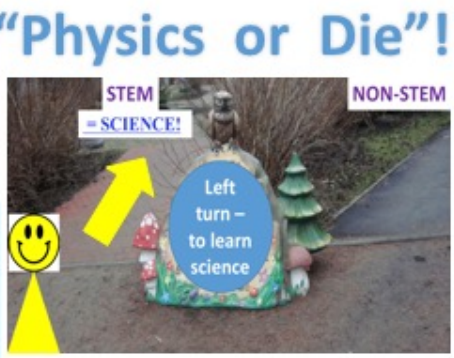


68. If we want to move the needle in STEM education, we need to make sure that by 2020 every middle and high school student could take physics. This task is achievable. However, it requires fighting a huge amount of a social inertia among teachers, school and district officials, policy makers, business community.

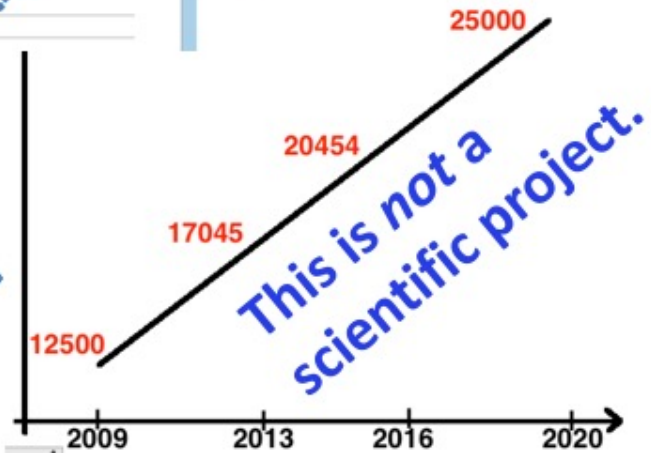
We cannot achieve this goal by just reasoning. This is *not* a scientific project.







By 2020 every middle and high school student should be take physics



69. In general, there are three kinds of human practices or projects: (a) a scientific research; (b) engineering and art.

"Becoming a STEM Teacher"; Chapter 4
https://www.smashwords.com/books/view/665204

Human Practices

Scientific *Research* → discovering new *knowledge*

Engineering and *Art* → building new *devices* or developing *artifacts* of art

70. And there are social projects: The goal of a social project is to change the existing social structure.

No person can do it alone. A social change can be achieved only by a group! That is why everyone who believes in this goal should join forces, should form a team, or an association.

Please, let me know if you are interested.

GoMars.xyz/2020.html

71. Thank you for your participation! We are almost done.

https://www.gofundme.com/teachology

https://teachologyforall.blogspot.com/

72. This is the summary of the talk. One last poll and this event will be over!

1. "What is so special about STEM education?"
It is based on the use of a *scientific way of thinking* (which is best represented in physics)
2. "*What* do students try to avoid by NOT going into STEM education?"
Doing science
3. "*Why* DON'T students want to do SCIENCE!"
They are afraid to fail.
4. What is "Science?"
***Mission* => *predictions*. *Functioning* => search for *patterns*.**
***Patterns* => found via *data* analysis (using *parameters* with measurable values)**
Similar conditions => observe similar patterns.
5. "How to move STEM?" Via a "club" for physics to ALL!

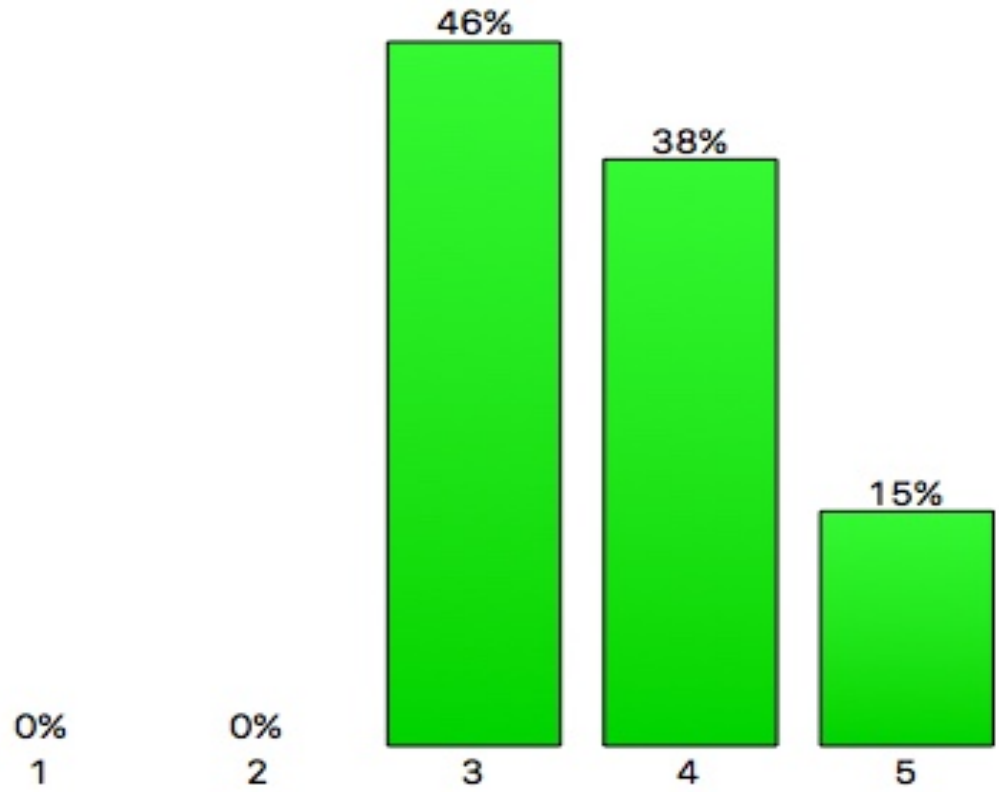
73. And this is the last question.

On a scale from
0 (not at all)
to
5 (very useful)
how useful was this presentation to you?

Thank you!

GoMars.xyz/end.htm valbu@bu.edu

Our last distribution!



Thank you!