How Can the History and Philosophy of Science Contribute to Contemporary U.S. Science Teaching

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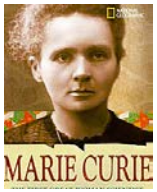
USING SCIENTISTS' HISTORY TO MOTIVATE STEM LEARNING

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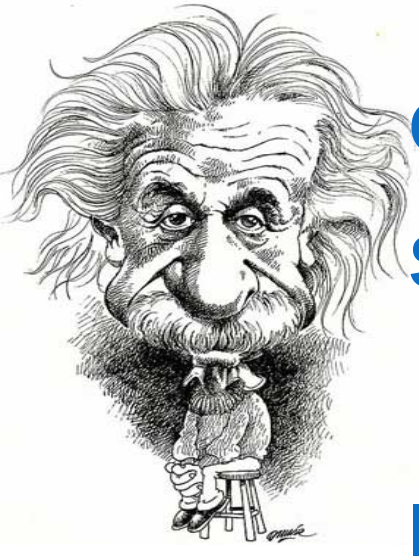


Only Smart people can do science.

Smart people don’t struggle with science

I struggle with science, therefore

I am not a smart person,

I can’t do science, and

there is not much I can do about it…

These are harmful mindsets to STEM motivation

- Inadequacy of one's own ability
- A fixed mindset about brain and intelligence

We Claim:

- Using external rewards to make STEM learning fun can only take us so far
- All STEM learners run into difficulties
- You can grown your own intelligence

Our Hypothesis

- Learning histories about scientists' struggles

  Helps students see that even great scientists struggle just like they do

  Offers intrinsic motivation needed for students to persevere through their own difficulties

  Helps students understand what takes to succeed in science—a much needed reality check

How Learning About Histories of Scientists' Struggles Improves Physics Learning

Hong & Lin-Siegler (2011), Journal of Ed. Psychology

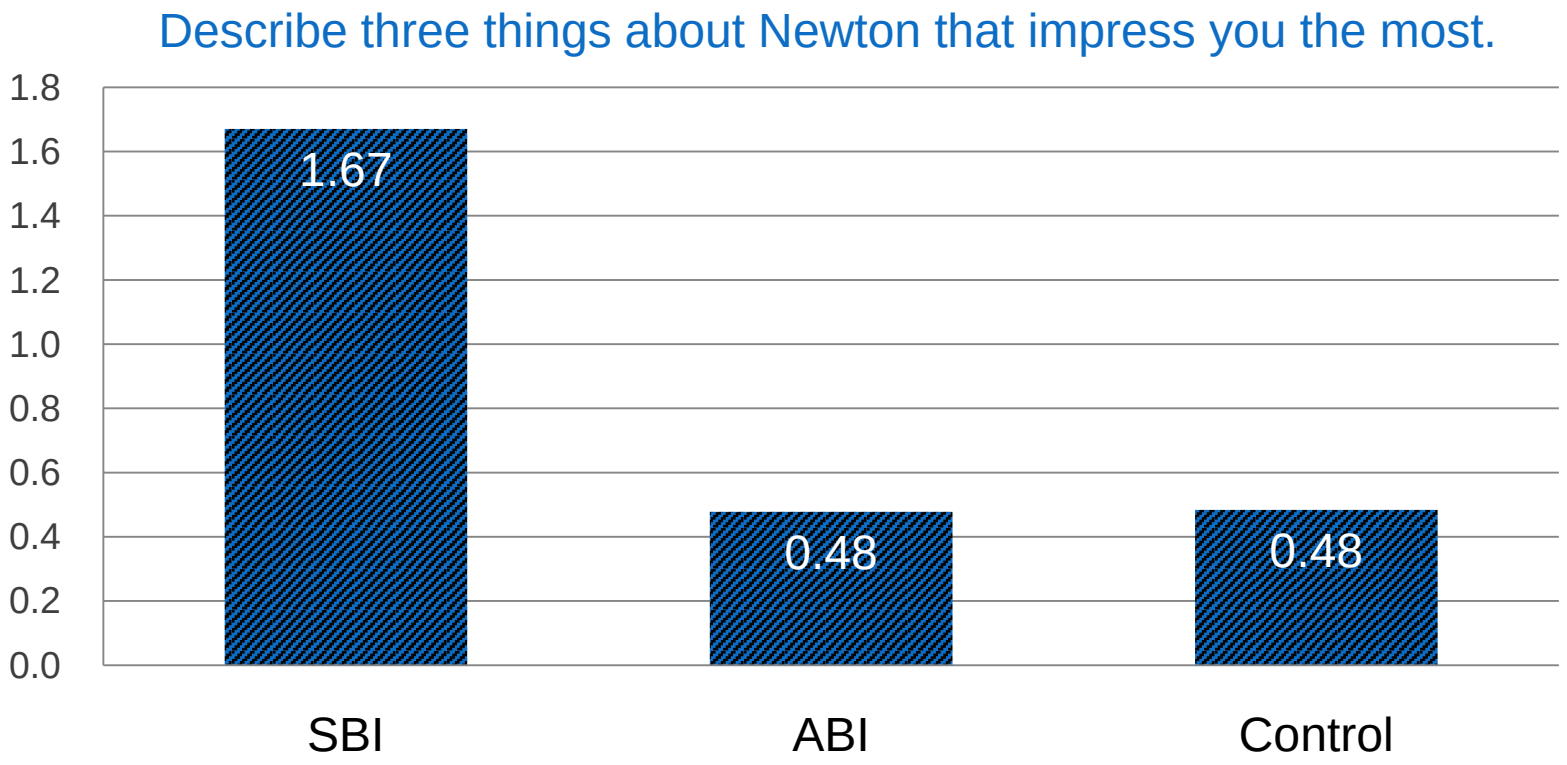
- Independent variables: different types of stories
- Dependent variables:
  - Perceptions of what takes scientists to succeed
  - Interests in physics
  - Beliefs in one's own ability
  - Recall of key physics concepts learned
  - Simple problem solving
  - Complex problem solving

Research Design:

- 323 10th grade students were randomly assigned to one of three conditions:
  - Achievement-oriented stories
  - Struggle-oriented stories
  - Control condition (more content knowledge is provided)
- Biographical stories about three scientists:
  - Galileo, Newton and Einstein
- All students received three identical on-line physics lessons

What It Takes For Scientists To Succeed

Struggle-oriented impressions, “even accomplished scientists struggled…”



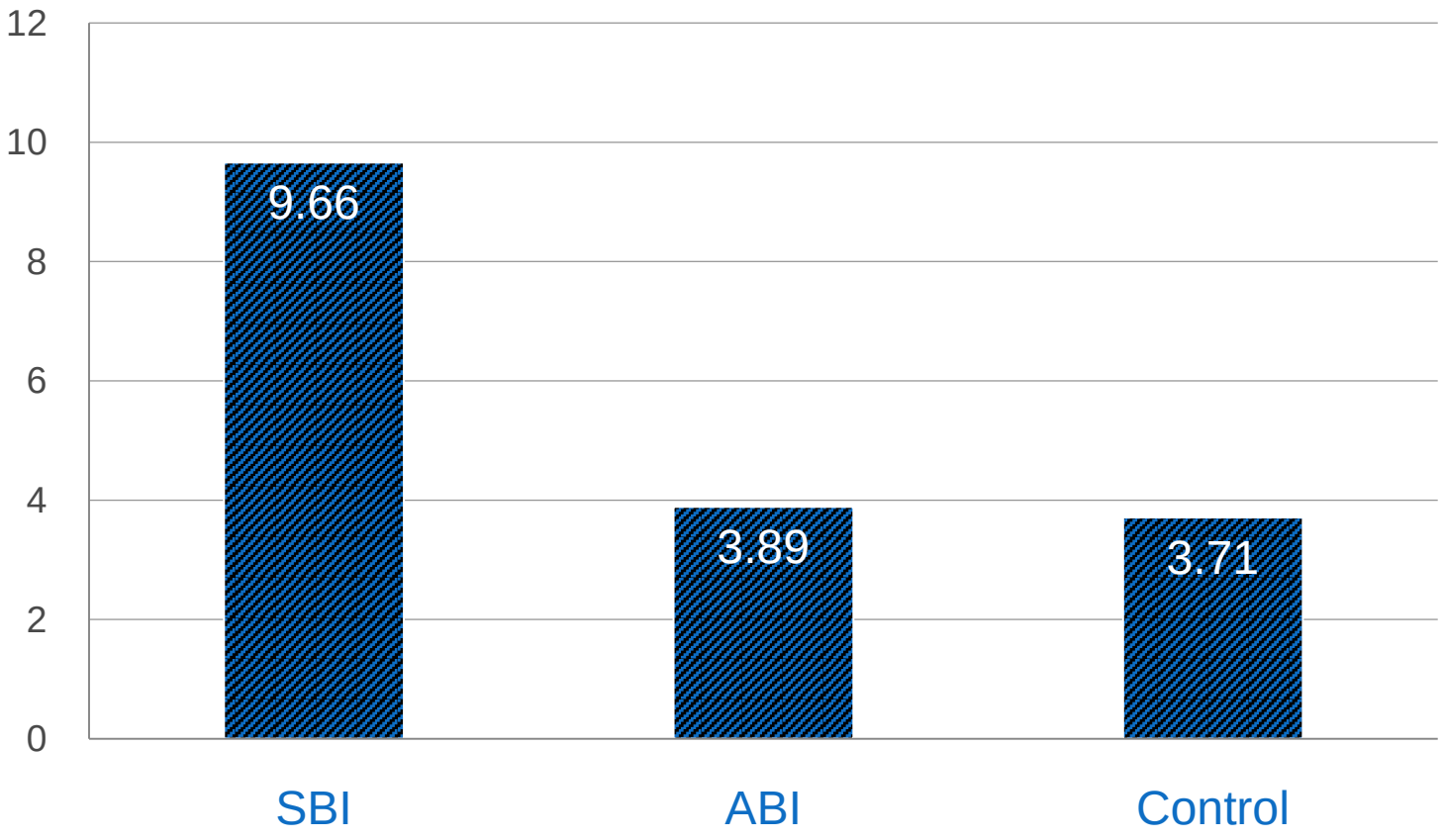
Interest In Science

Among students who had little initial interest, reading struggle stories increased their interest in the physics lessons.

Complex Problem Solving

- Two physics teachers developed seven open-ended questions to measure students' ability to explain relationships among scientific laws/theories.
- For instance, "How is Einstein's theory ($E=MC^2$) related to the Law of Conservation of Energy and the Law of Conservation of Mass?"; or "How is Galileo's law of free fall related to Newton's theory of gravity?"

Reading Scientists' Struggle Stories Did Improve Complex Problem Solving



Social Historical Sources of Motivation

- C. Dweck's work on knowledge about brain plasticity
- G. L. Cohen's work on value affirmation
- D. Oyserman's work on identity-based motivation
- C. Steel and J. Arosen's work on historical stereotypes

  None of these studies focus on extrinsic reward/punishment or increasing the appeal of instructional materials

Three Conclusions:

- History of science is important for STEM learning, so are the histories about scientists
- Types of scientists' histories matter
- More attention should be given to scientists' histories in school curriculum

Next 5 Years

- NSF REESE large empirical studies:

Developing students' growth mindset to promote motivation and science problem solving

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Classroom-Based Mindset Intervention: Two Approaches to STEM Motivation

- Social historical approach

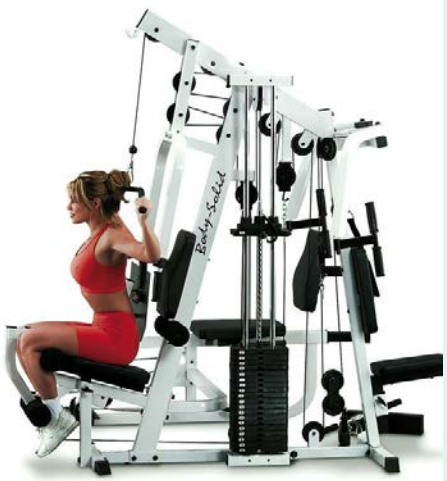
  How does learning about scientists' struggles through historical stories improves motivation and science problem solving?

- Cognitive and neuroscience approach

  Our brain, like a muscle, gets stronger with exercise. How does learning about this type of growth improve motivation and science problem solving?

- 1500 NYC students will participate our studies

How Brains Develop?



It's important to give your brain a workout too!

So how does your brain work?

You probably already know that when you lift weights your muscles get stronger (and bigger!).

Recent studies have shown that your brain is a lot like a muscle—it changes and gets stronger when you use it and learn new things.

<< previous

Coordination takes constant practice.

When you learn new things you make new connections in your brain, and that's how it gets bigger and smarter!

But, this also means that if you stop challenging yourself and stop practicing, your brain gets weaker.

How Does your Brain grow?

Thinking hard helps your brain grow.

You are the master of your brain.

Every time you learn, your brain grows.

That means **YOU** are in charge of HOW MUCH your brain grows. The more you think, and the harder you think, the smarter you get.

An Important Message:

- Everyone, even accomplished scientists, must work hard to achieve.
- We can grown our own brain and intelligence through efforts

Our Goal Is To

- Build bridges between cognitive neuroscience, and social historical instructional science to enhance motivation and science problem solving.
- Wisdom Is Needed!, Please Help US!