**Observing and Correcting Bias in Science Examples and Problems**

**Overview**

A key part of science is questioning assumptions, but all too often in the design of questions, problems or examples, faculty may have hidden assumptions that bias the instruction toward students with backgrounds similar to that of the instructor. Most problems and questions assume some prior knowledge, but is that prior knowledge or experience more common in some groups than others? Could these hidden assumptions contribute to deterring underrepresented students from pursuing STEM degrees?

**Context for Analysis and Discussion**

Many problems, questions and examples in science classes draw on “real world examples” which are intended to make the classes more engaging, interesting and relevant. Such examples also are intended to illustrate scientific points by drawing analogies with subjects that are familiar to students. However, a subject that may be familiar to the instructor may not be at all familiar to a student who comes from a very different background. In fact, many such examples may make the scientific points more confusing since the students must first try to understand unfamiliar terms and ideas specific to the given example.

How can instructors be more sensitive to the background knowledge and experience of diverse students? How can these factors be taken into account when designing problem sets, examples and exams? How can examples and problems be made more inclusive or be more fully explained to people who may not be familiar with the situations described?

**Examples of Bias and Ideas for Correcting Bias**

Here we present examples from problem sets (presented in Ref. [1]) that assume some background knowledge that may tend to be more prevalent in certain groups (e.g., white males) than other groups (e.g., women and people of color).

For the first problem we offer some suggestions and strategies to improve the wording of the problem to make it more accessible to a diverse audience. Perhaps the most important step is to be aware of unintentional bias in homework and make a concerted effort to reduce it whenever possible!

* *The 200-kg steel hammerhead of a pile driver is lifted 3.00 m above the top of a vertical I-beam being driven into the ground. The hammerhead is then dropped, driving the I-beam 7.4 cm deeper into the ground....*

A primary issue with this statement is that many students may not be familiar with the terms “pile driver” and “I-beam” since these technical terms are used primarily in the context of construction work. In particular, this statement would tend to differentially impact women, since construction is a field that is at present overwhelmingly male (according to the National Association of Women in Construction about 90% of construction workers are male).

Perhaps the simplest strategy to improve the statement of the problem is to remove as many unnecessary terms from the problem statement as possible, and rely on terms that have been discussed and defined in the class’s lectures and texts:

*A 200-kg mass is lifted 3.00 m above the top of a vertical pole that is being driven into the ground by repeatedly dropping the mass on the top of the pole (much like a hammer drives a nail into a piece of wood). When the mass is dropped on the top of the pole, the pole is driven 7.4 cm deeper into the ground…*

Another approach would be to carefully define and explain the new terminology and include clear diagrams. However, it should be noted that if there are repeated problem statements that are biased toward students of a particular background, this will tend to make understanding problems much simpler for some students than others.

Therefore, when writing problems based on real-world examples, it is advisable to be aware of bias and make a concerted effort to choose problems based on a variety of examples from different cultures and contexts.

For example, the following problem from the second edition of **Physics for Scientists and Engineers** by Randall D. Knight presents a real-world example from a Latin American country:

*The century-old ascencores in Valparaiso, Chile, are small cable cars that go up and down the steep hillsides. One car ascends as the other descends. The cars use a two-cable arrangement to compensate for friction: one cable passing around a large pulley connects the cars, the second is pulled by a small motor. Suppose the mass of both cars (with passengers) is 1500 kg…*

Here are some other examples of homework and exam problem statements with unintended bias:

* The motor of a table saw is rotating at 3450 rev/min. A pulley attached to the motor shaft drives a second pulley of half the diameter by means of a V-belt. A circular saw blade of diameter 0.208 m is mounted on the same rotating shaft as the second pulley. . . .
* A uniform strut of mass m makes an angle θ with the horizontal. It is supported by a frictionless pivot located at one-third its length from its lower left end and a horizontal rope at its upper right end. A cable and package of total weight w hang from its upper right end. . . .
* Fig (000) shows two disks: one (A) an engine flywheel, and the other (B) a clutch plate attached to a transmission shaft. . . .
* This is called elastic hysteresis. Rubber with large elastic hysteresis is very useful for absorbing vibrations, such as in engine mounts and shock-absorber bushings for cars. . . .
* One way to think about the definition (of a limit) is to suppose we are machining a generator shaft to a close tolerance. We may try for diameter L, but since nothing is perfect, we must be satisfied with a diameter f(x) somewhere between L − ε and L + ε. . . .

**The Importance of Peer-to-Peer Learning**

Many studies have shown the educational effectiveness of peer-to-peer learning strategies for all students, but it is important to note that peer-to-peer learning is also an extremely effective way to reduce unintentional bias in STEM instruction [2]. Research at the University of California at Berkeley showed that the pass rate for African American students in Calculus courses improved dramatically when the courses were taught using a workshop approach where the students worked together on homework in small, collaborative groups using in a structured format [3]. Similar approaches at the University of Texas improved grade point averages of African American and Latino students in Calculus from 1.67 to 3.53 [3]. There are a host of other studies validating these conclusions.

Thus one of the most impactful ways to combat bias in instruction is to encourage and facilitate peer-to-peer learning.

See, for example, <https://sites.google.com/site/quickpltl/> for ideas.

**References**

[1] James Trefil and Sarah Swartz, *Problems with problem sets*. Physics Today **64**(11), 49 (2011).

[2] Craig E. Nelson, *Student diversity requires different approaches to college teaching, even in math and science.* American Behavioral Scientist **40**(2), 165 (1996).

[3] U. Treisman, *Studying students studying calculus: A look at the lives of minority mathematics students in college.* The College Mathematics Journal, **23**(5), 362-372 (1992).