TEFA Question Content

TEFA works best with question cycles that focus on key concepts students can reason with and argue about

Ian D. Beatty, Scientific Reasoning Research Institute, University of Massachusetts Amherst

The first, most obvious decision we face when designing a question for instruction with *Technology-Enhanced Formative* Assessment (TEFA) is what portion(s) of the subject content the question will focus on. We must answer the question "What is to be taught?"

Three general considerations are relevant. The first is *time*: in most situations, we don't have the luxury of using TEFA to dig deeply into every piece of our mandated curriculum, thoroughly exploring students' thinking and developing lengthy discussion of each subtlety. Nontrivial student cogitation requires time — often more than one would expect — and worthwhile discussion takes even more time. So, we want to focus TEFA questions on a vital subset of the course content. The rest must be addressed more shallowly, using "abridged" TEFA or other methods, relegated to outside-class learning through textbook reading or other homework, or sacrificed.

(It is worth noting that the "formative assessment" aspect of TEFA, finding out what your students think and what they do or don't get, can help make high-velocity survey-style coverage more efficient. But that's not TEFA's primary intent.)

The second consideration is *yield*. We want to focus on content that will spark, or at least allow, learning-generative discussion in which multiple viewpoints

Breadth vs. Depth?

Compared internationally, US curricula in science and mathematics have been characterized as "a mile wide and an inch deep." Textbooks grow thicker, standards documents insist on "authentic" learning and reasoning skills but mandate ever more topics, and high-stakes exams assess for quick recall of facts and performance on stock question types. What's a well-meaning teacher to do?

Aside from complaining loudly and frequently about the curricula, standards, and exams, we recommend renouncing the *myth of coverage*: the idea that what a teacher "covers" in class matters. Only what students *learn* matters, and formative assessment is the only way to measure and optimize that.

We also recommend helping students build a good foundation of core conceptual understanding and thinking skills, and "topping them off" with the specialized and more factual bits later or outside class — which should be easier with a solid base.

are voiced and explored. This suggests that we choose topics "meaty" enough that earnest students can disagree about them, with nontrivial reasoning behind their opinions. Matters of fact, definition, and straightforward procedure tend to fall into the "you know it or you don't" category, which rarely leads to worthwhile discussion.

The third consideration is *utility*. We want to focus on content that will be most useful to students: content that will help them make sense of other ideas, that will help them understand the subject in an integrated way, and that will help them analyze situations, figure things out, and *think* a little more like a biologist, chemist, mathematician, or similar expert in the content.

These considerations suggest that we use TEFA question cycles to target the key concepts and organizing principles of the topic.[1] These "big ideas" are the foundation upon which students assemble structured, expert-like, transferrable knowledge.

(We do *not* mean to say that you should never ask TEFA questions about simple matters of fact, or that every TEFA question cycle must address some huge overarching idea. We do believe, however, that focusing much of your TEFA effort on key concepts can help you to be happier with the results.)

Identifying a topic's key concepts is often challenging. In textbooks and standards documents, they can get mixed with definitions, details, procedures, examples, and special cases in one undifferentiated mess.

When trying to identify the core concepts of a subject, it's very easy to start listing topics or sub-topics instead of ideas. What's the difference? One way to think of it is that a topic or sub-topic is something you want students to know *about*; a concept, principle, or idea is something you want them to know, to get, to apprehend as one mental construct. (Often, the same word is used for a concept and a topic. For example, in Physics, "energy" can mean the abstract but very important physical quantity — a concept — and it can also mean the general topic of everything having to do with that quantity and how it's used.)

Most concepts have an articulable definition, but understanding and being able to apply the concept flexibly requires knowing more than just that.

In Physics, energy is an elusive but crucial concept for students to get, as are the related ideas of "conservation of energy" and "energy dissipation." For working with forces, "reaction force" and "constraint force" are subtle but necessary.

In Chemistry, "stoichiometry" can be considered both a topic, a concept, and a bundle of tightly interconnected concepts.[2] "Equilibrium" is also a likely candidate for TEFA focus.

In Anatomy & Physiology, "homeostasis" is a central concept, connected to "buffering." "Diffusion" and "osmosis" are additional vital concepts. Even "interior to the body" and "boundary of the body" are nontrivial. (Is something in the stomach "inside" the body?)[3]

In Algebra, "function" or "functional relationship" is fundamental, and related to "slope." Similarly central is the idea that an equation is somehow "the same" after applying the same mathematical operation to both sides, even though it looks completely different. "Linear," "nonlinear," and "exponential" are related concepts.

What matters is not identifying the "right" concepts to target with TEFA, but rather attempting to focus at that level. Getting stuck at the level of definitions, facts, and procedures is a trap we can all fall into.

---

[1] See TEFA Note #1, "What is TEFA?"

[2] Thanks to Sacheverell Seney of Frontier Regional School, South Deerfield, MA.

[3] Thanks to Donna Canuel-Browne of Northampton High School, Northampton, MA.

This material is based upon work supported by the National Science Foundation under grant numbers DUE-9453881, ESI-9730438, and ESI-0456124. The opinions, findings, conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the National Science Foundation.