The Smarter Balanced Common Core Mathematics Tests Are Fatally Flawed and Should Not Be Used

An In-Depth Critique of the Smarter Balanced Tests for Mathematics

Steven Rasmussen
SR Education Associates
March 2015

www.mathedconsulting.com
steve@mathedconsulting.com

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Introduction

In 2010, like many educators, I was hopeful that a $330 million investment of tax dollars from the U.S. Education Department and the pooled resources of state governments[1] would produce a new generation of standardized tests for assessing student performance on the Common Core State Standards for Mathematics and English language arts—tests that would be better than the traditional paper-and-pencil multiple-choice tests. Both Smarter Balanced and PARCC, the Education Department's contractors, promised technology-enhanced tests populated by high cognitive-demand tasks with interfaces that made smart use of digital tools for mathematics to more deeply assess student knowledge. Smarter Balanced, with an award of $176 million[2], promised to "create innovative and real-world item types that rely on technology platforms."[3]

In early 2012, Smarter Balanced contracted with CTB/McGraw-Hill (CTB) for $72 million[4] to build the tests we'll see this year. CTB enlisted partners, including the American Institutes for Research, to assist with the "development of technology-enabled test items and new open-source scoring engines as well as research into new item types."[5] In October 2014, after a field test with 4.2 million students that "closely resembled the summative assessment that students will participate in during the spring of 2015,"[6] Smarter Balanced published a self-congratulatory report titled *Smarter Balanced "Tests of the Test" Successful: Field Test Provides Clear Path Forward*. Although the report contained very little discussion of the technology-enhanced items overall, it stated:

> *These item types appear to have caused little problem for the large majority of students, although educators raised concerns about those without access to technology at home. Interestingly, the youngest students reported the greatest ease with navigating the items and entering responses.*[7]

While neither the tryout tests nor their detailed results have been officially made public, summary analyses from Smarter Balanced, as well as nationwide and local news reports following the field test, indicated that things had not gone well. Christina Samuels, in an *Education Week* blog post on January 2, 2015, reported that Smarter Balanced predicts results will be poor when the tests are given in the spring:

> *Based on the field test results, the consortium estimates that fewer than half of all students will be able to demonstrate proficiency by scoring at level 3 or above when the test is first administered, though test officials expect those scores to rise over time.*[8]

Alarmed by these troubling signs, concerned about the impact of poor test scores on my profession, and skeptical that any vendor could craft high-quality technology-enhanced tests in the short time allotted in the contracts, I decided to take a close look at the Smarter Balanced practice and training tests available online at www.smarterbalanced.org/practice-test.

The landing page for these tests reads:

> *Welcome to the Smarter Balanced Practice and Training Tests*
>
> *The Smarter Balanced Practice and Training Tests are available to schools and districts for practice and training purposes, professional development activities, and for discussions with parents, policymakers, and other interested stakeholders.*[9]

I clicked through the links, randomly chose the practice test for tenth grade mathematics, and clicked "Yes, Start My Test."

What I found shocked me. This analysis of mathematics test questions posted online by Smarter Balanced reveals that, question after question, the tests:

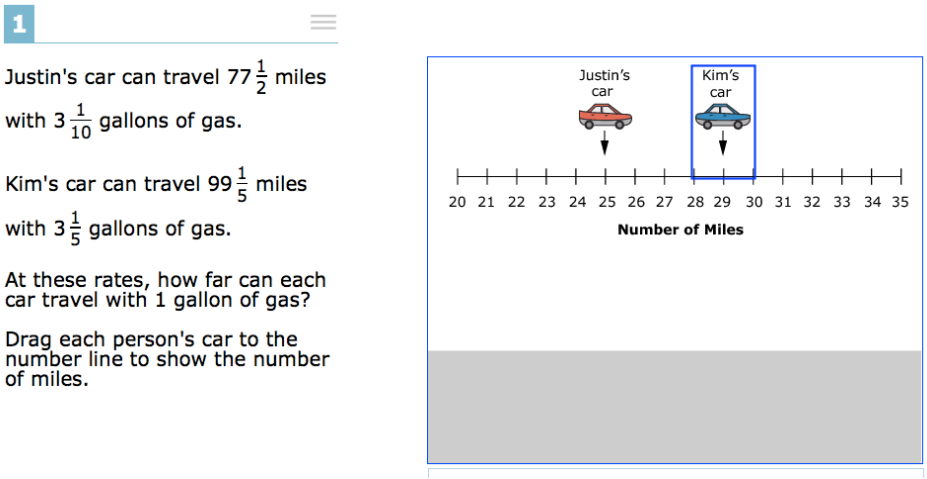
- Violate the standards they are supposed to assess;
- Cannot be adequately answered by students with the technology they are required to use;
- Use confusing and hard-to-use interfaces; or
- Are to be graded in such a way that incorrect answers are identified as correct and correct answers as incorrect.

If the technology-enhanced items on the Smarter Balanced practice and training tests are indicative of the quality of the actual tests coming this year—and Smarter Balanced tells us they are[10]— the shoddy craft of the tests will directly and significantly contribute to students' poor scores.

Smarter Balanced Practice Test Items

You can follow my critique of the first five items from the Smarter Balanced tenth grade math practice test to get a clear picture of the problems.

Tenth Grade Practice Test, Question 1



Before I even attempted to answer Question 1, I was troubled by its premise. It begins with a mathematical contrivance: who uses fractions—fifths of gallons and miles—when discussing fuel consumption? Odometers display decimals rather than common fractions. So the problem context starts off as immediately insincere. The question then speaks of "these rates," but no *rates* are given. A *rate* for this question—according to the Common Core itself—would have the unit "miles per gallon." Remember, Mathematical Practice 6 is *Attend to precision* per the Common Core's Standards for Mathematical Practice.[11]

Further, students are asked to do two almost identical calculations to obtain the correct answer to this question, doubling the chance of a careless error from a student who knows how to do the problem.

When I solved the two parts of the question on scratch paper, I suspected something funny was going on—both of my answers were whole numbers: 25 and 31. How likely is it to get two whole numbers when dividing mixed numbers? And how even less likely are whole-number answers in any real-world driving context? The fact that both answers turned out to be whole numbers made me question my work. This will be very unnerving to students who would expect to get a mixed number as a result of these calculations. Question 1 will make an anxious student more anxious.

Then, as I went to indicate my answers, I was simply confused by the technology I was seeing. The "innovative" technology here is a dynamic number line—a digital manipulative familiar to me for which I've developed many compelling applications while working with *The Geometer's Sketchpad*, and which I know has a deep research pedigree going back at least to Paul Goldenberg's Dynagraphs project. But Question 1 has nothing to do with elementary number theory, proportion, continuity, the real numbers, or any of the other mathematical concepts that dynamic number lines are productively used for. The problem simply tests a procedural skill—division of mixed numbers—and the dynamic number line is used only as a mechanism for filling in a blank with a specific value, and a whole number value at that. *This* was supposed to be an innovative use of mathematics technology? The technology "enhancement" has nothing whatsoever to do with the actual problem. A multiple-choice response would serve this question perfectly well.

As I reflected on the problem and played with the number line, my initial confusion about the number line's apparent lack of relevance turned into eye-opening concern.

When I dragged one of the "answer cars" to the number line, I was surprised to discover that when I let go of it, the car jumped to a nearby number before coming to rest. I tried again—with the same result. What I was seeing was some form of "snap-to-points," where the technology "corrected" my answer to the nearest whole number on the number line. "Why?" I wondered. And what are the implications of this snap-to behavior?

First, the snap-to behavior comes as a complete surprise to any user. When you drag the car and then let it go, the snap causes the car to jump left or right by up to half a mile on the number line, locking in to a value other than the one you chose. It's counterintuitive and unsettling. If a student calculates an answer that is *not* a whole number, then she simply cannot represent her answer in this test. Worse, a student who believes her non-integer answers to be correct will be frustrated and confused when the test "changes" her answers to values she did not intend. "Those weren't my answers—why can't I show *my answers*?"

Second, the snap-to behavior is mathematically inappropriate for what Question 1 is asking. Mathematically, snap-to behavior is a rounding function—in this case, the snap rounds any answer to the nearest whole number. But Question 1 does *not* ask for answers rounded to whole numbers. And it wouldn't make sense to ask for rounded answers in a problem about fraction division where exact procedure is being tested.

Third, a *discrete* snap-to interaction space ("interaction space" is the Smarter Balanced name for the place on a technology-enhanced item where students perform an interaction to indicate their answers to a question) is the wrong model for the *continuous* function

describing gas consumption. On a Common Core test that adheres to CCSSM Mathematical Practice 4: *Model with mathematics,*[12] it's worth getting mathematical models right.

Mathematical Practice 2: *Reason abstractly and quantitatively*, reads, in part:

> *Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them;….*[13]

Judged by this standard, at this point in my analysis, Question 1 isn't performing well.

The more I played with Question 1, however, the more I realized how poorly conceived the question's interaction space was. It could actually misinterpret students' intentions and interfere with our understanding of their work. The number line snap will convert an infinite number of incorrect answers into a correct answer. For example, if a student calculates 25 1/5 as the mileage for Justin's car and drags the car to this spot, Justin's car snaps to 25—the correct answer. The test's scoring mechanism wouldn't know the student calculated incorrectly. Any answer a student calculates between 24½ and 25½ becomes a correct answer. Huh?

But simply turning off the snap won't cure the flaws in Question 1—in fact, doing so would only create other problems. How do you locate a mistaken answer like 23 7/31 on a number line drawn to this scale if you wanted to? With no snap, how would the scoring algorithm know what fraction a student wants to indicate?

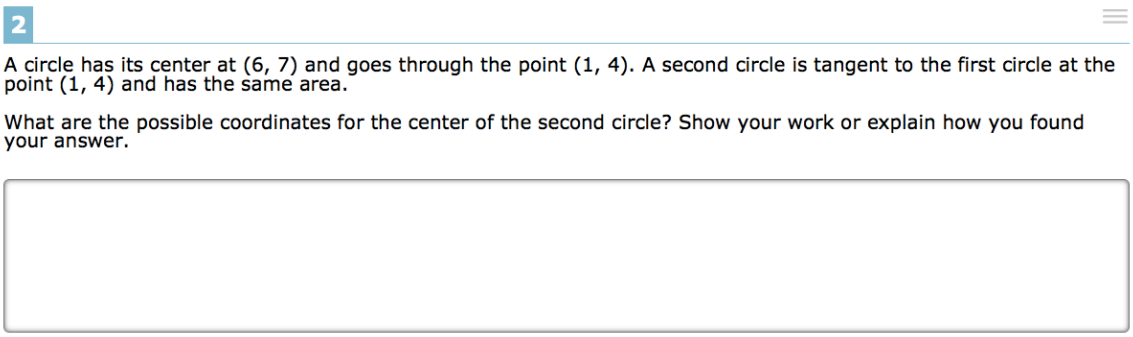
If the test makers gave information in decimal fractions—like an actual odometer—and the problem was testing division with decimal numbers, a number line without snap would be appropriate. In such a case, CTB would have defined acceptable tolerances for the location of the "answer cars" according to the process set out in the document *Smarter Balanced Assessment Consortium: Technology-Enhanced Items Guidelines*. These guidelines, authored by Measured Progress/ETS Collaborative at the outset of Smarter Balanced's work, and presumably followed by CTB, state that, for this type of question, "appropriate tolerances should be determined through cognitive labs and/or field testing."[14]

So the problem is not just that the number line behavior needs fixing; it's that a number line is the wrong tool for answering Question 1. Asking students to display the exact results of division with fractions on a tiny number line marked only in whole units — whether it "snaps" or not—is like asking students to eat soup with a fork to determine whether they know how to eat.

So while innocuous at first glance, Question 1 *mis*models the mathematics of the given problem; and if you answer the problem incorrectly, depending on your answer, the test may (a) accept it, (b) autocorrect it (e.g., 25 1/5 becomes 25), or (c) auto-*dis*correct it into some other wrong answer (e.g., 25½ becomes 26)! In terms of the insight we gain into students' performance by examining their test results, we can't tell what a right answer means because the system corrects many wrong answers into right ones. And we can't tell what a wrong answer means because it may not be the student's wrong answer, or, if it is, the result does not let us identify which of the many mathematical skills contributing to a successful solution the student actually got wrong.

While the test makers might think that the dynamic number line adds cachet to an otherwise traditional problem, analyzing this test question demonstrates that they are in over their heads when it comes to the design of technology-enhanced items.

Practice Test: Tenth Grade, Question 2



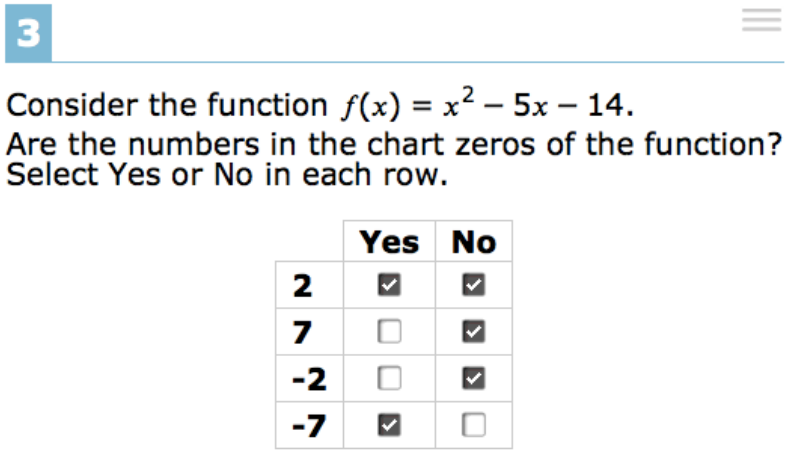
In Question 2, the test makers ask students to solve a geometric problem and show their work. In general, asking students to show their work is a good way to understand their thinking. In this case, would anyone begin the problem by *not* sketching a picture of the circles? I doubt it. I certainly started by drawing a picture. A simple sketch is the most appropriate way to show one's work. However, there's just one major issue: *There is no way to draw or submit a drawing using the problem's "technology-enhanced" interface!* So a student working on this problem is left with a problem more vexing than the mathematical task at hand—"How do I show my picture by typing words on a keyboard?"

Clearly whoever wrote the test question saw how nonsensical the "show your work" admonition was, and added, "… or explain how you found your answer." So I start typing my answer: "First I drew a circle centered at point (6, 7) that passed through the point (1, 4). Then I…." It doesn't take very long to wonder, "Are the test makers playing a cruel joke on me?"

Question 2 asks students to solve the problem and then conceptually re-engineer their solutions in order to accommodate the limitations of the testing machine and the test design—all while the test clock is ticking.

Give me a grid and a circle-drawing tool if I am to show circles on a coordinate plane! Let me use a dynamic-dragging representation—like the one they misused in Question 1—to drag a dynamic circle to its correct position and size on a given coordinate system. Asking students to communicate their thinking should be done in fair and appropriate contexts. This one is neither.

Tenth Grade Practice Test, Question 3



3

Consider the function $f(x) = x^2 - 5x - 14$.
Are the numbers in the chart zeros of the function?
Select Yes or No in each row.

	Yes	No
2	☑	☑
7	☐	☑
-2	☐	☑
-7	☑	☐

Question 3 amplifies the "careless error" possibilities present in Question 1. Even though there are only two zeros of the function, a student who correctly finds them must carefully click in four checkboxes to indicate his answer: "No" in the first row, "Yes" in the second, "Yes" in the third, and "No" in the fourth.

Suppose, however, a student makes the common mistake of identifying 2 and –7 rather than –2 and 7 as zeros of the function. That student likely checked the wrong box in every row. But perhaps in the last minutes of the test, while reviewing his answers, our student catches his mistake and tries to correct it. (You might think of this as one mistake that results in four incorrect answers.)

To simulate this situation, I initially checked the wrong boxes in each row, and then, to correct my mistake, I clicked the "No" box for the *x*-value 2 in the first row. Much to my surprise, "Yes" remained checked in the first row! Instead of "No," my answer is now "Yes" and "No." You can see this in the picture above. You will be hard pressed to find another digital interface where a binary choice (a choice with an either/or response) requires checking two boxes. Typically, an "or" question conforms to the standard digital interface of either a single checkbox, or a radio button that automatically unselects "Yes" when a user selects "No." But that's not how this problem was designed.

So our student, who is rushing to correct his mistake, must realize that this user interface is unconventional and click twice properly in each row—once to check the right box and a second time to uncheck the wrong box—eight clicks in all.

Phew! Try purposely messing this problem up and then try correcting your answer. The silly interface will make you dizzy—even when you know the right answer. It feels like a trap.

Rather than using checkboxes or radio buttons, what if the test makers had instead asked, "Find all zeros of the function *f* where $f(x) = x^2 - 5x - 14$," and offered two blank boxes for input? Not only is this a better question, it likely requires less keyboarding.

To gain insight into the original thinking about how a Yes/No question was supposed to work, one can refer to early test design guidelines in the document *Smarter Balanced Assessment Consortium: Technology-Enhanced Items Guidelines*, developed by the Measured Progress/ETS Collaborative (April 16, 2012):

> ***Boolean:*** *A binary variable with two possible values: true and false. These variables can be used to indicate the preference for any characteristic that has two states, e.g., on/off or yes/no. For example, whether a default coordinate grid should be displayed on an item can be specified by the item writer as yes (true) or no (false). Whether a student is limited to choosing one item or is allowed to choose multiple items can be specified by the item writer as limited (true) or unlimited (false).*[15]

This makes total sense. But it was not how Question 3 was implemented by CTB. And the implementation of Boolean logic in a computer interface ought to be trivial.

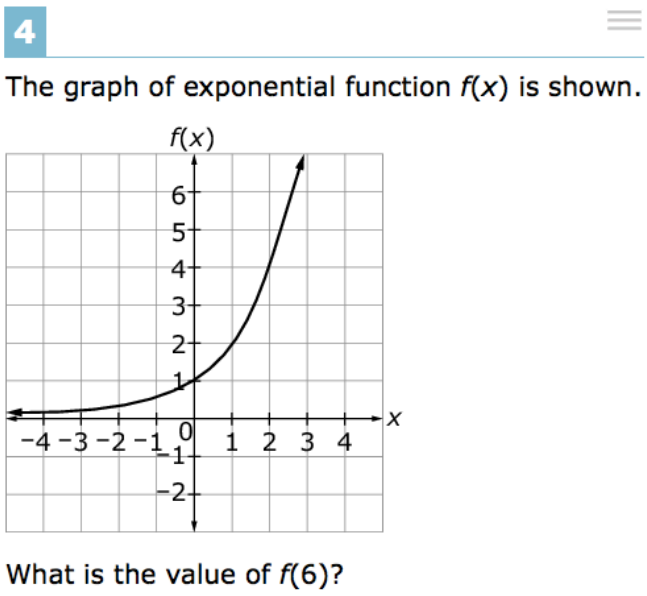
The guidelines also set forth how the score of a single question might rely on the answers to subparts of the item:

> ***Composite Set (of Items):*** *A composite set is composed of multiple individual items (either technology-enhanced items, technology-enabled items, or traditional items), with each item containing its own interaction, score response set, and scoring algorithm. The items within the composite set are presented to the student together. Each individual item returns an individual score that is independently calculated (i.e., the scoring of one item response is not dependent on the response to a prior item). The score of the composite set is based on a combination of the scores from each independent composition. To determine the composite set score, a composite set includes a scoring algorithm that defines how scores from the multiple individual items are combined to provide a single composite set score.*[16]

Could it be that Question 3 was implemented as a composite of eight individual responses corresponding to the eight independent checkboxes? Even when the answer to the question is simply two integer values?

At some point between April 16, 2012, and now, a simple, well-specified interface idea turned into a nightmarish implementation. Smarter Balanced quality control[17] failed.

Tenth Grade Practice Test, Question 4



The wording on Question 4 is sloppy. It should read, "The graph of an exponential function *f* is shown." The question claims $f(x)$ refers either to a *function* or to a *graph*. But it is neither. The *function* would be simply *f*, its *graph* might be $y = f(x)$, and the question's $f(x)$ refers instead to the *value* of the function at x. As phrased, the question is mathematically comprehensible—but it misuses the mathematical terminology CCSSM expects students to use correctly by tenth grade. (The previous question also used sloppy language. The wording should have been: "Consider the function *f* given by $f(x) = x^2 - 5x - 14$.")

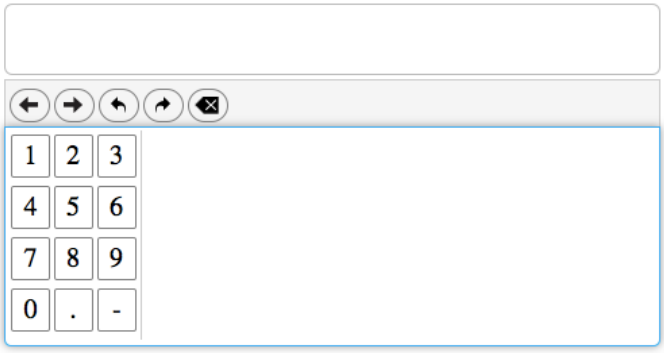
Additionally, there are multiple types of exponential functions, not just one as the question implies.

In Question 4, students must determine the equation of the function shown through the visual information in its graph. The equation is clearly supposed to be $f(x) = 2^x$ and thus $f(6) = 64$. But actually, the function is only "kind of" 2^x. After $x = 2$, the curve appears as a straight line. No way the arrow is going to make it to (3, 8)! Also, $f(-2)$ is not ½ and $f(-2)$ is clearly closer to $^1/_3$ than to $^1/_4$. The graphic on this question was obviously not created using mathematical software. The graph is inaccurate and misleading.

Despite all of this, I like the question that the test makers thought they wrote.

However, as soon as I tried to input my answer, I was dismayed by what I saw. While it is possible to simply type 64 in the answer space for Question 4, the test makers have also offered a graphical keypad for inputting one's answer with a series of mouse clicks (officially, the "Equation Response Editor tool." Why a graphical keypad here? As seen with Question 2, students are asked to input the coordinates of a point in a text box (e.g., an ordered pair of numbers, either of which may be negative) and then follow it with a typed essay explaining the answer. So undoubtedly the test makers expect that students can type "64" on a computer keyboard. In Question 4, a graphical keyboard is therefore unnecessary and inconsistent with the way students input their answers in Question 2.

To make matters worse, the graphical keypad is obviously poorly designed. It's confusing on the surface, and inscrutable "under the hood."

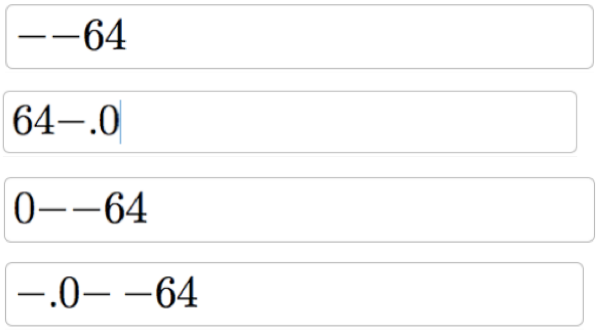


First, I wondered why there were so many buttons on it and what they each did. The five arrow buttons above the numbers—three leftward and two rightward pointing arrows—look so similar that their actions can only be deciphered through trial and error. (I'll list their functions here to save you the effort of experimenting: move cursor left, move cursor right, undo last action, redo last undone action, and delete digit to the left of the cursor.) Only the last of these buttons—Delete—is needed. If one wanted more buttons,

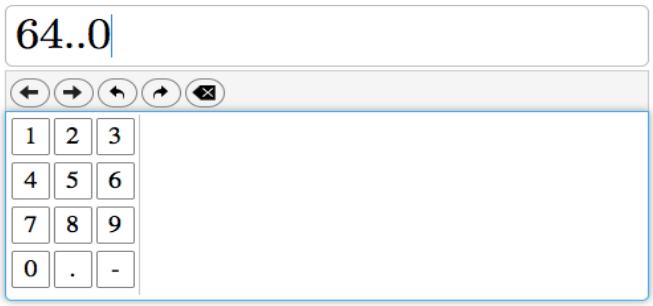
Delete All might be a nice addition and correspond to the Clear and All Clear keys students are familiar with on calculators.

Second, is the last key on the keypad a subtraction key or a key for inputting a negative number, or can it be used for both purposes? It acts a lot like a subtraction key—you can enter "65–1" for instance—but you can press it repeatedly and display many subtraction signs—like a negative key. I wondered whether "65–1" would be evaluated by the parser as 64. Unfortunately, it's impossible to figure out what this key actually does mathematically. That's why I call it "inscrutable."

Like "65–1,"all of the inputs below might equal 64. Would they be accepted as correct answers to Question 4? Who knows?

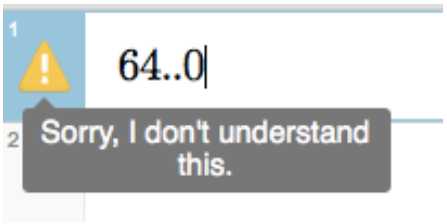


Third, if a student using the keypad inputs an answer such as the answer below, it's likely the student made a typing mistake. Calculators typically don't allow more than one decimal point in a number—precisely to prevent silly typing mistakes. There is no benefit to this question in allowing typing mistakes.



It can be argued that a generalized interface for mathematical input should allow arbitrary and unrestricted input. After all, when a student does mathematical work with a pencil on paper, there are no restrictions on the numbers and symbols that can be combined. The extent to which a computer interface accepts arbitrary input, especially in mathematical programs, is a fascinating and open question in user interface design. Every software developer will answer this question differently. I have spent long hours in discussions regarding the educational tradeoffs between arbitrary vs. constrained input over the course of my career in software development, and seldom is the exact right course obvious. However, all good software designers agree on two points: programs should be consistent and they should provide user feedback in some manner as to whether input is mathematically understandable and acceptable to the program. Neither consistency nor helpful user feedback is present in the Smarter Balanced-CTB design.

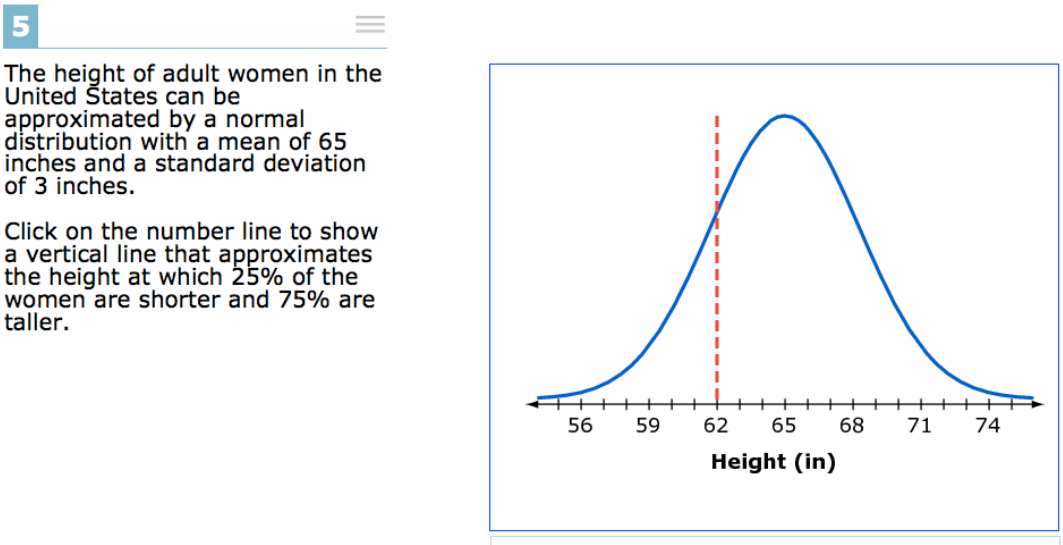
Desmos (www.desmos.com) is a popular online graphing calculator for education that offers such feedback. Here is a typical Desmos entry box if a user enters "64..0" with its keypad.



Interestingly, for the mathematical input in its application, Desmos uses MathQuill, an open source mathematical rendering library. From the apparent behavior of the Smarter Balanced practice and training tests, it seems that CTB also uses MathQuill on the tests it produced for Smarter Balanced. But Desmos has put thought and programming behind the mathematical rendering library, offering an elegant solution to the conundrum, "Is it bad typing or bad mathematics?" CTB didn't bother to do this work. And student scores will suffer as a result—for no good reason. In the Smarter Balanced tests, mathematically incorrect answers, typing mistakes, as well as mathematically valid answers entered in unconventional ways, will all be treated equally.

So in Question 4, too, the design that CTB implemented for Smarter Balanced penalizes struggling students. Students at ease with the mathematics and familiar with computer input interfaces will breeze through Question 4—they need only correctly type "64." But a student who struggles with the math, makes a mistake or two, and tries to correct his mistakes may get mired in the ridiculous interface, especially if he is tempted to input his answer with the graphical keypad. It reminds me of the saying, "The rich get richer…."

Tenth Grade Practice Test, Question 5



Question 5 starts off poorly. A normal distribution doesn't approximate *a* height, it approximates a distribution of many heights—in this case over 100 million.

When I read Question 5, I was immediately suspicious of the data based on the numbers in the problem. To make any sense, an actual analysis of the spread of women's heights would have to measure heights with more precision than the problem indicates.

Remember, CCSSM Mathematical Practice 2: *Reason abstractly and quantitatively* states in part:

> *Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them.*[18]

Curious how the data were actually reported, I searched the Internet and found a document of the Centers for Disease Control and Prevention (CDC)[19] that reports recent data on heights of women in the United States. The aggregated mean of women over 20 in the CDC sample is 63.8 inches—not 65. All reports of heights of women in inches I found from any authority reported heights to tenths of an inch—a choice of precision appropriate for this problem. (Only one subgroup in the CDC data has a mean height that would round to 65—non-Hispanic white women 20 to 39 years in age. Hmm…. This ought to be a warning that gross errors in reporting data carry certain biases!) But apparently, the actual numbers as reported in tenths of an inch would be inconvenient for this question. Instead, Question 5 throws valid statistics to the wind and "approximates" the actual curve so that both the median and the standard deviation are integers—and so that even the correct answer for Question 5 based on the concocted data, 62.977 (found using http://stattrek.com/online-calculator/normal.aspx), is very nearly an integer. One wonders how many made-up scenarios the test writers explored to come up with a question that almost completely eliminates the messiness of real data.

Once I got past my concerns about the data and precision, I began to think about how I was going to answer the question. Question 5 seems designed to align with CCSSM High School Statistics and Probability Standard HSS.ID.A.4, which states, "Use calculators, spreadsheets, and tables to estimate areas under the normal curve."[20] (It's the only Common Core standard on the topic of standard deviation.) A statistician would use one of these tools. But no spreadsheet, table, or statistical calculator is provided, so that couldn't be the method the test makers had in mind.

Since the problem says, "Click on the number line to show a vertical line," I clicked. You'll see the vertical line I got in the picture above.

This line might be helpful to students who are trying to figure out how to divide the area under the curve so that 25% is to the left of the line and 75% is to the right of the line—except that students cannot drag the dashed line; they can only click the number line below it and watch the dashed line jump to the integer value nearest their click. What a convenient input method this is: it simultaneously communicates to students that an integer answer is required, and implies to students that height (though graphed so as to appear continuous) is actually a discrete variable, not a continuous one! This inappropriate treatment of the height variable is presumably motivated by the need to mark students' "approximate" answers categorically as either correct or incorrect. While mathematically more logical, a vertical line that moved continuously wouldn't work like a multiple-choice input method—and that's what this question ends up being.

Look carefully at the areas to the left and right of the vertical line at 62 in my picture. Can you tell me with assurance that 62 is *not* an excellent approximation of the "height at which 25% of the women are shorter and 75% are taller"? I think it is an excellent approximation given the visual information. The question doesn't ask for an approximation to a specific level of accuracy. But I'm certain that 62 is not the answer that this question is looking for. Otherwise, the test writers wouldn't have fudged the data

to get an answer that came out close to 63. They must have wanted me to put the line at 63. (Interestingly, the CDC data also reported that the first quartile for all women, asked for here, is about 61.9 inches—so 62 is closer to the *real* answer to this question than 63.)

In the absence of a table or statistical calculator, visually estimating the areas under the curve would be an excellent way to answer this question. This method, however, makes no use of either the mean or the standard deviation or even the fact that the curve is a normal distribution. The question done by my method becomes simply an area estimation question. All a test-taker needs to do is estimate where the line puts 25% of the area on the left.

How else might a student answer this question in the absence of the tools statisticians would use? If a student studied normal distributions, she might know that about 68% of the cases lie within plus and minus one standard deviation of the mean (e.g., from 62 to 68), and from this, determine that the area to the left of the 62-inch mark therefore represents about 16% of the total? Does she then further guess that the interval between 62 and 63 appears to contain the additional 9% required to make 25%? Probably not. Given that only integer answers are possible, she'd probably just guess the answer 63 because 64 just seems too close to the mean. Is this really what the test makers wanted her to do? If so, her response to this question relies on recalling a single fact about the relationship between the normal distribution and standard deviation and noticing the odd behavior of the number line.

Beyond the issues on this question that relate to statistics, the snap-to behavior of the number line butchers the elegant and fundamental mathematics related to calculus that underlies the normal distribution curve and it's relationship to the aggregated area under the curve as one moves along the *x*-axis. The mechanism chosen by the test makers for students to indicate their answers indicates clearly how little important mathematics the test makers actually understand. For a detailed discussion of this issue, read the boxed test at the end of this critique.

Before leaving this problem, let me use two students with two hypothetical answers to illustrate concretely why an interaction space with a number line that snaps to integers fails for this question as it did for Question 1 of this practice test.

The answer to Question 5 is very close to 62.977. For my argument, I'll choose two hypothetical answers from the set of possible answers that are close to this number. I realize that I am choosing extreme cases. Suppose Student A thought that that the answer was 63.49, for whatever reason, and clicked this point. The vertical line would appear at 63. Now suppose Student B thought that the answer was 62.49 and clicked there. This answer would appear as 62. I imagine that the test would consider Student A's answer to be correct and Student B's answer to be incorrect. But actually, Student B's answer ($P(X \leq 62.49) = 0.20139$) is a tiny bit closer to the correct answer than Student A's ($P(X \leq 63.49) = 0.30736$). The interaction space behavior can make worse answers right and better answers wrong. With other percentages, where the distribution curve is less linear, this behavior could be more of a problem.

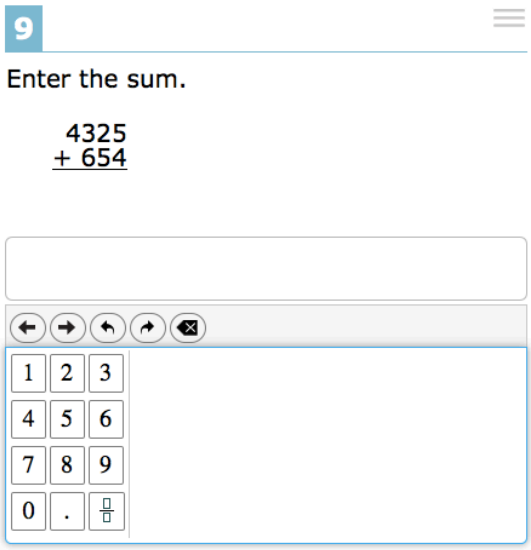
Movable lines in graphs of data can be used productively in many circumstances to gain insight in statistics. *This* moveable line on *this* snap-to number line in *this* poorly crafted question neither works to help students nor works to help us understand what students know or don't know about normal distributions and standard deviation.

Tests at Other Grade Levels Are No Better

I began this analysis with the first five items of an arbitrary practice test—I chose the tenth grade practice test—because I didn't want it to seem that I "cherry picked" questions to complain about. The poor craft, however, is not confined to this single test. The problems run through all of the tests. Below I've picked three questions from the fourth grade practice test and one question each from the third and eleventh grade tests to critique.

In the fourth grade practice test you'll see many examples of the clumsy keypad for numeric input—almost identical to the one we saw above on the tenth grade test. Except, on the fourth grade test, the test makers seem to think every keypad needs a fraction key—even when it is mathematically ridiculous to consider fractions as a possible answer.

Fourth Grade Practice Test, Question 9



In a whole-number addition problem, why offer a keypad with a fraction key? And why offer such a complicated keypad that resembles a calculator but builds numbers in the opposite direction from the calculators kids likely use in school? (Calculators push digits left, while this keypad works in the opposite direction.)

Mathematical Practice 5: *Use appropriate tools strategically* reads, in part:

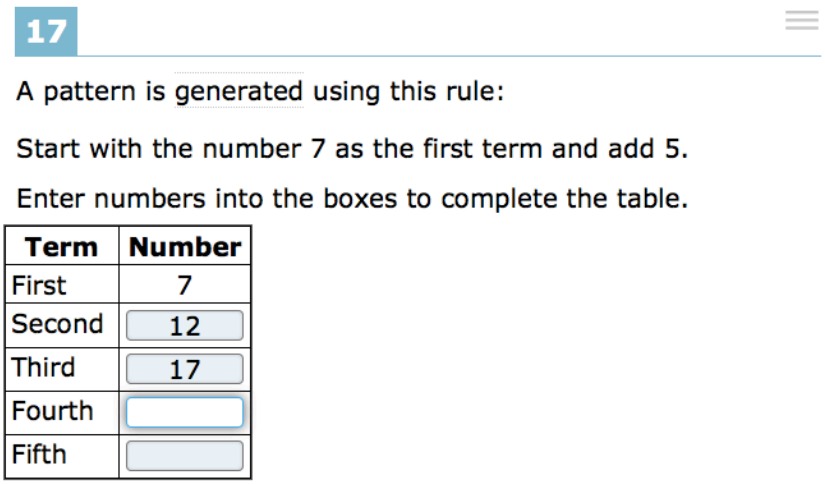
> *These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations.*[21]

On an addition problem like this one, the interface should be simple. If it's just a question of typing digits, leave it at that. One doesn't need something that resembles a calculator but doesn't calculate and works in the opposite direction. (Later in this critique you'll find a link to a video that shows fifth grade students struggling to make sense of this graphic keypad. You can see how it gets in the way of inputting simple answers. I

question how much user testing was done with kids during the design process of this and other interface elements of these tests.)

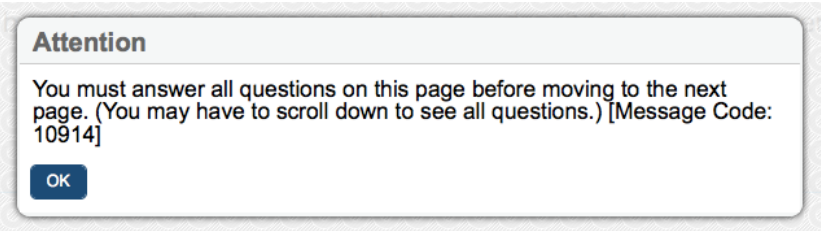
I'm sure that the test makers would defend themselves by saying that this keypad is used throughout the fourth grade test and that they wanted a consistent tool so that students could use it regardless of the situation—a tool that allows the user to make whole numbers, numbers with decimal points, and fractions. That doesn't justify, however, the overly complex design (five arrow buttons). Nor is this claim sustainable. Looking across the fourth grade practice, there is no consistency. Other items, Questions 17 and 13 below for instance, use different interfaces for numeric input. The consistency argument doesn't stand up.

Fourth Grade Practice Test, Question 17



With Question 17, the test makers abandon the keypad we saw in Question 9 of the fourth grade test and insist you type numbers on your keyboard instead. (If there's a reason the keypad is "strategically appropriate" for entering four-digit whole number responses in Question 9, but not a two-digit number in Question 17, I missed it.) So much for consistency.

But this apparently simpler interface has critical problems that go beyond inconsistent design. If a student fills in the first two boxes in the sequence as I have above, but is stumped by the fourth element in the series, he is locked in "enter-numbers-in-boxes" purgatory. The test clock is ticking. Anxiety is rising. And when he tries to advance to Question 18 without filling in the last two boxes, he'll receive the message I received when I tried this:



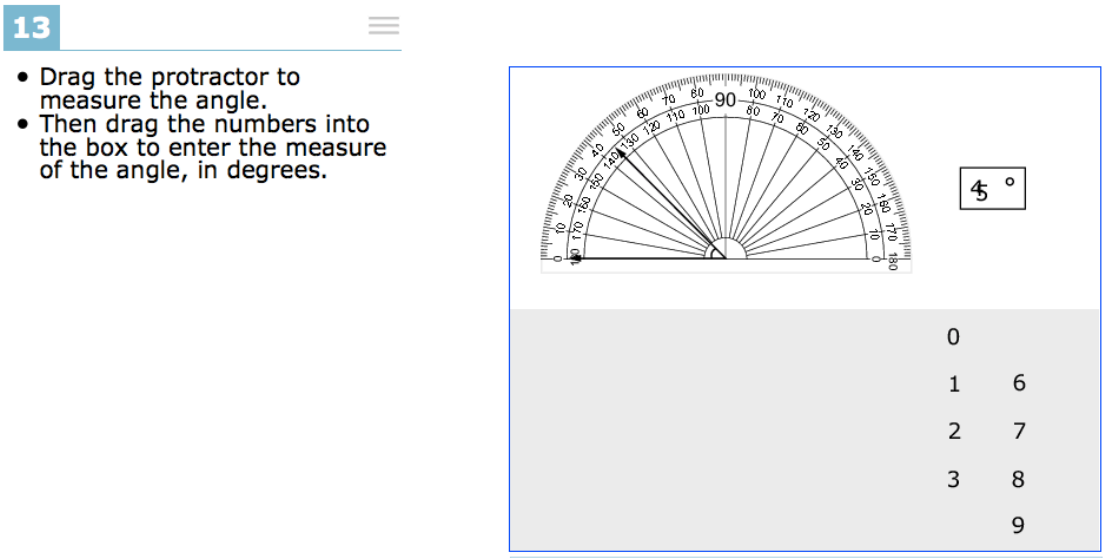
Our poor student is stuck on Question 17. I imagine for some students, this is the end of the test—Message Code: 10914! Explain that to your parents.

This sort of design violates a central tenet of sound test-taking advice we give our students, which is to stay collected, keep an eye on the clock, skip parts that you're stuck on, and come back to them at the end when you have time. It also violates a central tenet of sound computer interface design—avoid highly modal interfaces (of which Question 17 is one clear example)—dating back at least to Apple's extensive critique of them in the celebrated *Macintosh Human Interface Guidelines* that accompanied the first-generation Macintosh and the dawn of the modern computer interface.[22] Users get stuck in modal interfaces.

Finally, the wording of Question 17 misses the fundamental notion of iterative sequences—the iterative process *continues*. The rule must state that explicitly. The question should have been written as: "Start with the number 7 as the first term and add 5 to get the second term. Continue to add 5 to each term to get the next." The "rule" given in Question 17 actually generates a finite sequence with exactly two elements: 7 and 12. I hope that the scoring engine for this problem insists that the third, fourth and fifth boxes be left blank. But if they are blank, a student cannot proceed. In other words, a correct answer to this question actually stops the test! Please, test makers, "*Attend to precision*."

While Questions 9 and 17 of the fourth grade test raise serious concerns about the depth of thought given to the user interface by the test makers, Question 13 makes one wonder whether they have any knowledge of mathematics at all. It offers yet another way to input whole numbers.

Fourth Grade Practice Test, Question 13



I dragged the protractor to the angle and saw that the angle was 45°. Easy enough. Then I dragged two "numbers into the box" to show 45°.

Take a minute to appreciate what you see. Once used, a digit is no longer available for use again. What if I had wanted to show 44°?

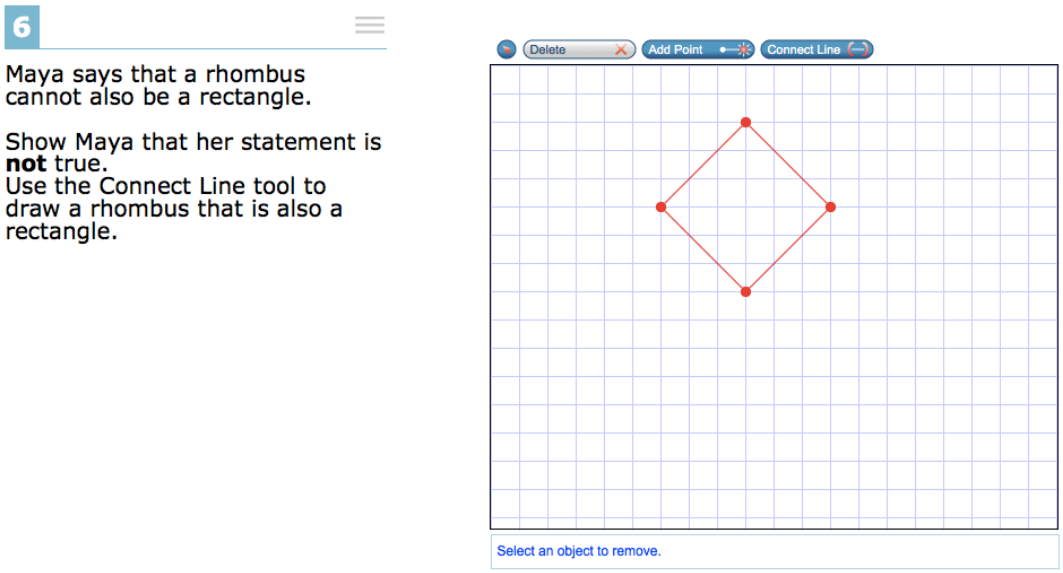
You'll see my digits in the box—a 4 and a 5—somewhat misaligned. Apparently, my juxtaposition of the 4 and the 5 was acceptable enough to the test interface that I could go on to the next question when I finished. (No modal problem here.) Now the loaded question: "Did I input 45?"

What possible mathematical purpose, conceptual insight, computational fluency, or procedural skill is revealed by having students express an arbitrary whole number by dragging digits from a finite supply of them into a fixed input field?

Conversely, how many unconstructive and even profoundly misleading ideas about basic number concepts can you see this interface as encouraging? Shall we express our numbers by arbitrarily dragging digits to the left and right of each other or above and below one another? Shall we think about the structure of the set of numbers that are expressible using no digit more than once? (Or maybe better still: shall we assume that there is a mathematical prohibition against angle measurements with repeated digits?)

If fourth grade math is about anything, it's about understanding place value. Even if the test parsed my answer correctly, misalignment and all, this interface is so egregiously "anti-place value" that it rises to the level of "anti-intellectual." It is an insult to mathematics teachers everywhere. Sadly, you'll find variants of this "anti-place value" interface sprinkled throughout the Smarter Balanced-CTB tests.

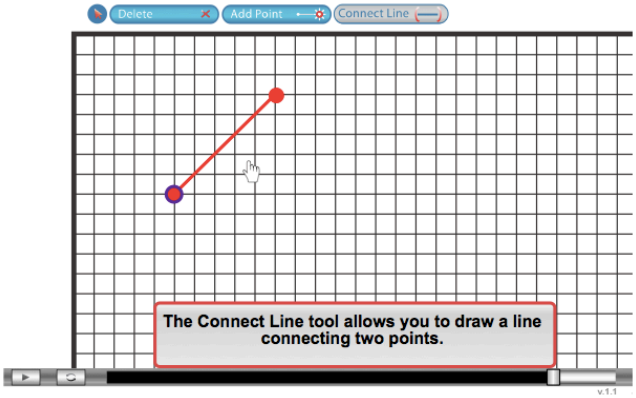
Third Grade Practice Test, Question 6



I would seriously question whether this problem is appropriate for third grade, but that discussion is outside the scope of this critique. Question 6 of the third grade practice test employs a simple drawing interface to input one's answer. It is a drawing interface that appears in a number of geometry questions across grade levels on both the practice tests and the training tests. The interface has four tool buttons: Arrow (for dragging points but not segments), Delete, Add Point, and Connect Line. Students are asked to use these tools to "draw a rhombus that is also a rectangle."

But wait, there are *no lines* in a rhombus—one draws a rhombus with *segments*. This is a distinction all geometry curricula insist we respect! Polygon edges are segments. A Draw Segment tool, a Use Straightedge tool, or a Draw with Ruler tool would all be appropriate possible tools to construct a rhombus, but not a Connect Line tool. And just what *is* a Connect Line tool anyway? If you think about it, what function does this name actually describe? A user connects *two* things, not one. Is it a Connect Lines tool? A Connect a Line to Something Else tool? In fact, it's a Connect Two Points to Make a Line Segment tool—with three-quarters of its name missing.

The tutorial for this tool helps us understand why this tool is messed up—apparently the designers didn't know the difference between a line and a segment themselves!



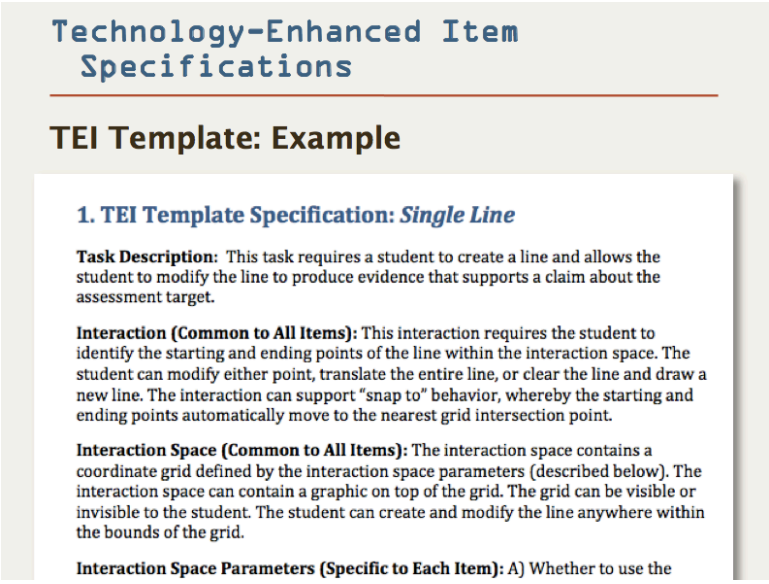
Am I being picky? Not according to Mathematical Practice 6: *Attend to precision*.[23]

Unfortunately, the misnamed tool is only the beginning of the issues with this "Frankenstein" drawing interface assembled thoughtlessly and arbitrarily from body parts of other drawing software programs. Some students will figure out how to use the drawing interface because they are clever and adept at navigating clumsy software. Students fed high doses of test prep specifically using this interface may fare OK when they encounter it on a Common Core test. (I only hope they have something better to use on every occasion when they are not test prepping!) But many students that try to use this interface to answer a test question, especially if they get off track and want to revise a drawing they have initially made, will be stumped and foiled by its lack of coherent design. When I tried to delete a segment using the interface, for instance, I couldn't do it. By trial and error I discovered that you had to delete points to delete a segment or you had to exactly line up crosshairs over a segment to get it to delete—hard to do on vertical and horizontal segments, nearly impossible on diagonal segments.

On the silly keypad used for number input, the interface programmers gave us an Undo button that no one will ever use. Here, where Undo would be very useful, there is no such button. Did the programmers ever discuss among themselves what they were doing, or were all of these interfaces programmed in isolation from each other? Never mind, I know the answer.

The bottom line is this: many students who know the answer to this question will be tripped up by this interface and get it wrong.

Interestingly, when I look all the way back to the first Smarter Balanced Showcase in January 2012 where Measured Progress/ETS shared their design specifications, I can see the origins of this geometric interface. Here is slide 62 of the PowerPoint for that webinar[24]:



Technology-Enhanced Item Specifications

TEI Template: Example

1. TEI Template Specification: *Single Line*

Task Description: This task requires a student to create a line and allows the student to modify the line to produce evidence that supports a claim about the assessment target.

Interaction (Common to All Items): This interaction requires the student to identify the starting and ending points of the line within the interaction space. The student can modify either point, translate the entire line, or clear the line and draw a new line. The interaction can support "snap to" behavior, whereby the starting and ending points automatically move to the nearest grid intersection point.

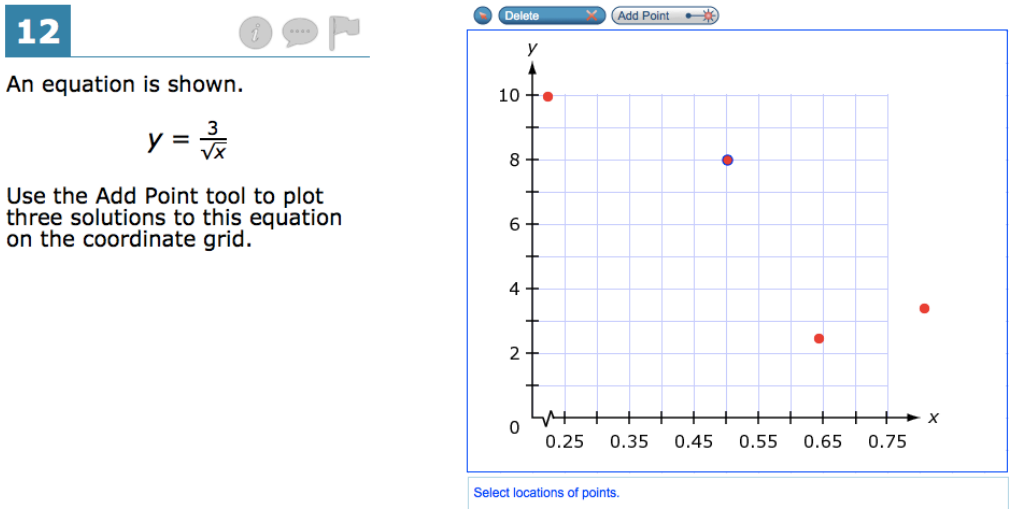
Interaction Space (Common to All Items): The interaction space contains a coordinate grid defined by the interaction space parameters (described below). The interaction space can contain a graphic on top of the grid. The grid can be visible or invisible to the student. The student can create and modify the line anywhere within the bounds of the grid.

Interaction Space Parameters (Specific to Each Item): A) Whether to use the

At the time, I had high hopes for this item genre. Dynamic geometry is a proven technology. Unfortunately, the poor implementation of this powerful idea has dashed my hopes for these tests.

Geometric tools are not the only poorly designed tools in these tests. The tests also make frequent use of a poorly designed graphing interface. Here's Question 12 from the eleventh grade practice test. I placed the red points shown on the graph. There is no snap-to behavior on this coordinate grid.

Eleventh Grade Practice Test, Question 12



In solving this problem, Question 12 of the eleventh grade test, a logical substitution to try would be 0.09 for x, as this yields an exact solution of (0.09, 10) for the equation. However, the x-axis uses a confusing representation to indicate "torn axes" as a way to reduce the space between 0 and 0.25—even while not "tearing" the grid itself. Does this mean that any solution with an x-value less than 0.25, such as (0.09, 10), is not permissible? If so, why isn't this region of the graph simply omitted? Assuming, as I have above, that 0.09 is an acceptable x-value for a solution, where should the approximate position of this x-value be shown? I have identified an easy-to-calculate solution to the equation, but I am stymied by the representation of the interaction space.

What is the upper limit of permissible *y*-values allowed? Is it 10? Is it 11? Why is the upper limit of *y*-values treated differently than the lower limit of *x*-values?

Why is the *x*-axis labeled in such an unorthodox way—with odd multiples of 0.05? Is it to direct a student to guess that 0.25 is an easy *x*-value to try? Why not 0.1, 0.2, 0.3, etc., as is customary?

I assume the test makers would consider the approximate solution (0.64, 3.75) to be correct. Is the approximate solution (0.81, 3.333…) shown above and allowed by the interface also correct even though it falls outside the grid?

It would be nice if the coordinates of a point were displayed at the cursor. This would help students place their solutions accurately without giving away answers.

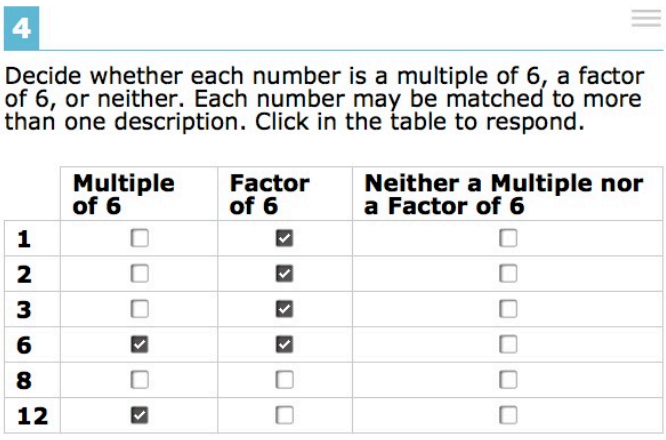
The item asks for three solutions. Does that mean that an answer with four points will be incorrect (as above with a non-solution point at (0.5, 8))?

The interface of Question 12 is modal. Until the user selects the Add Point button, it is impossible to answer the question. And upon using the Delete button, it remains selected and the user can only delete points. However, by selecting the Add Point button, not only can the user add a point, but also move a point. Moving a point is highly useful to complete the problem efficiently. Yet there is no clear indication as to how one moves a point or even that dragging is permitted. The confusion caused by the modal interface makes it difficult to demonstrate one's answer. Had the test makers displayed three red points to the side of the graph and asked students to drag the points to three places on the graph that represent solutions to the equation (removing the Delete and Add Point buttons), many of the interface issues could have been avoided. The interface would not be modal and it would be clear that exactly three points are desired. With this change, dragging points would be elevated to its proper place as a useful problem-solving technique in dynamic mathematical representations.

Smarter Balanced Training Tests

In addition to the grade-specific practice tests, Smarter Balanced provides training tests across several grade bands so that students can prep for the tests: grades 3 to 5, grades 6 to 8, and high school. There are fewer items represented on each of these training tests than on the practice tests. Hoping that these tests would be significantly better in quality than the practice tests, I reviewed all questions in each band.

Grades 3 to 5 Training Test, Question 4



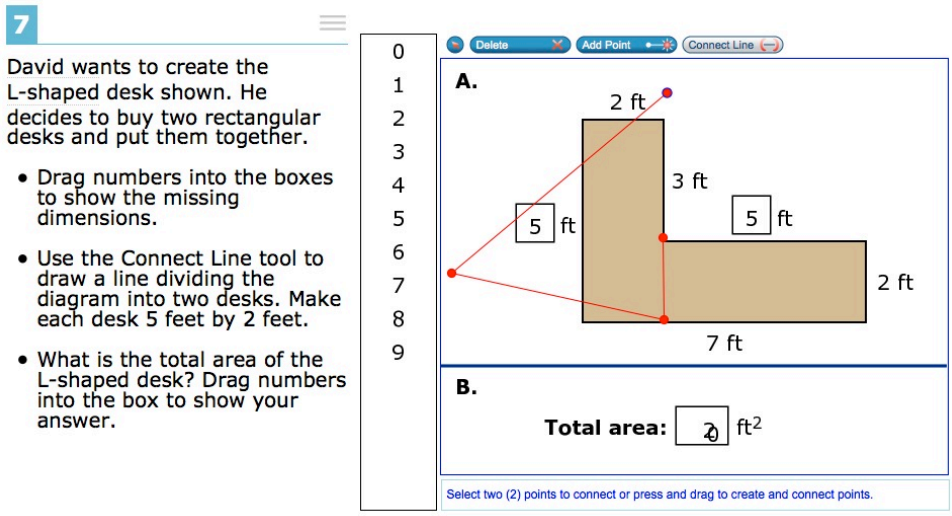
4

Decide whether each number is a multiple of 6, a factor of 6, or neither. Each number may be matched to more than one description. Click in the table to respond.

	Multiple of 6	Factor of 6	Neither a Multiple nor a Factor of 6
1	☐	☑	☐
2	☐	☑	☐
3	☐	☑	☐
6	☑	☑	☐
8	☐	☐	☐
12	☑	☐	☐

The checkbox quagmire, again, but with a new spin. Isn't the last column redundant? Apparently it's needed to tell the difference between a question that wasn't answered and one that was. Otherwise, if I left the 8 row blank because I forgot to fill it in, it might count as a correct answer. Surely, there are less convoluted ways to see if kids know multiples and factors of 6—like asking them for a couple.

Grades 3 to 5 Training Test, Question 7

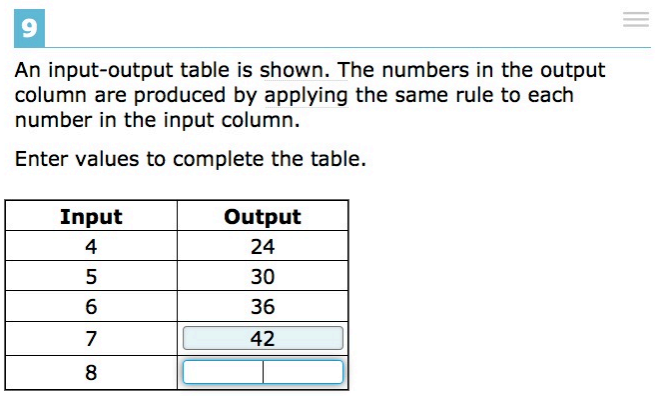


Question 7 rolls a variety of problems seen earlier into one item:

- You use a Connect Line tool to draw segments;
- Once depressed, the Connect Line tool is in "line" mode and you can't easily figure out how to stop it from drawing "lines";
- You pile digits in boxes to make base ten numbers; and
- To change an answer in a box you have to click on the Delete tool, enter delete mode, and then click on the digit in the box you want to delete (you have to click separately on both "2" and "0" to delete "20"), then go back to the Delete tool and click it again to leave delete mode, and then drag a digit or two to the box to indicate your new answer.

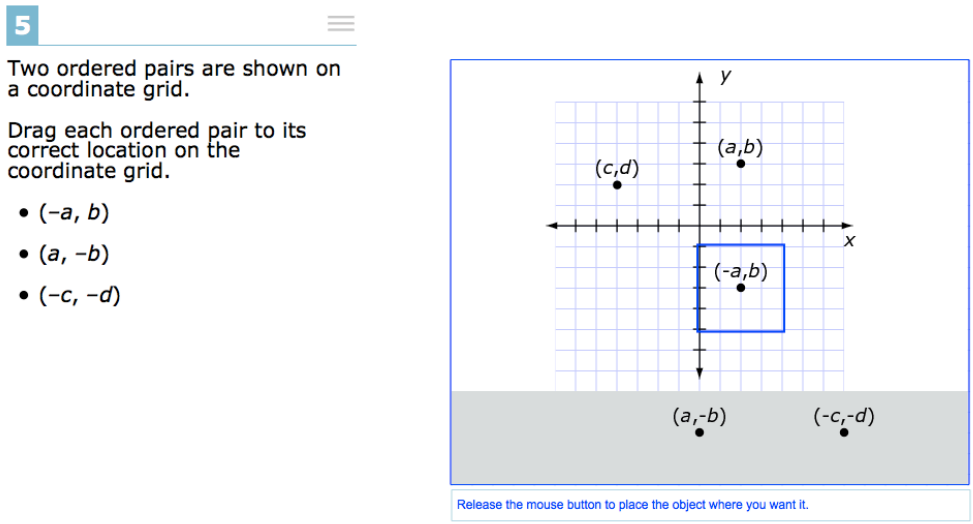
Unlike fourth grade Question 13 above, at least the test makers gave us an inexhaustible supply of digits to use in this problem.

Grades 3 to 5 Training Test, Question 9



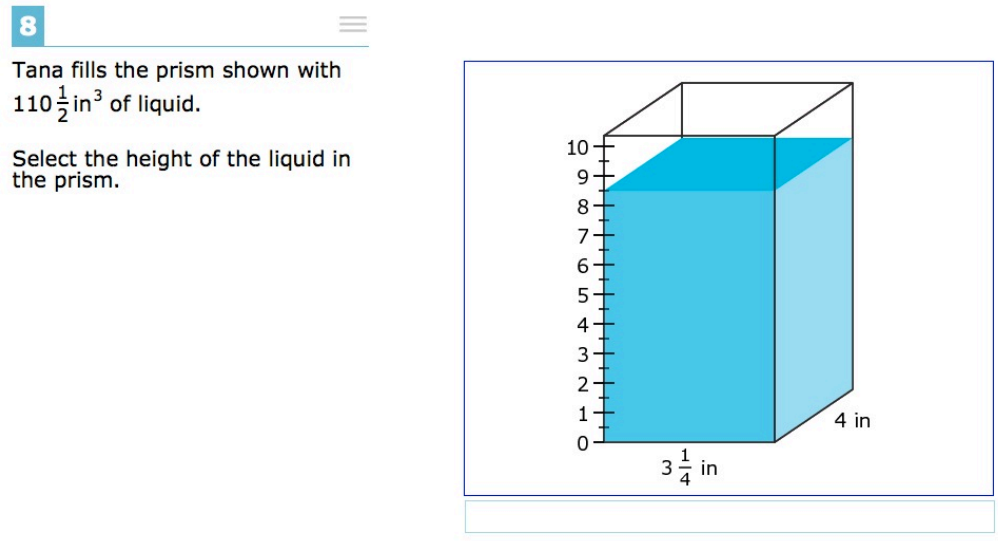
This question suffers from the same modal issues as Question 17 of the fourth grade test. Same "Message Code: 10914" when you try to move on before finishing your last answer.

Grades 6 to 8 Training Test, Question 5



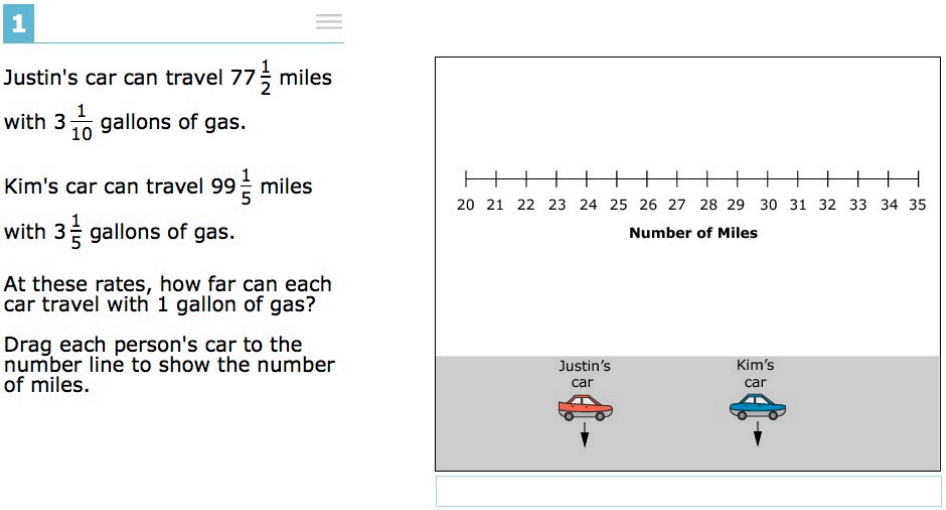
I like this question and the interface worked well!

Grades 6 to 8 Training Test, Question 8



This question is mathematically unanswerable as written. One cannot calculate the height of the prism without knowing the shape of the base. In order to calculate height as I suspect the test makers wanted, the prism must be a "*rectangular* prism" to specify that the prism has a rectangular base. If the prism is a rectangular prism, then the height is 8 ½. But there is an additional issue introduced by the way test makers want students to show their answer. If the answer above is what the makers wanted, because the height is marked on an edge of the prism, the problem must further state that the prism is a "*right* rectangular prism." Additionally, there are no units on the height and an entirely different scale is used. If the base is measured in inches, the height certainly is not. *Attend to precision* (Mathematical Practice 6)!

High School Training Test, Question 1



Oh, no! The cars again. On the high school training test you'll find that Smarter Balanced recycled the tenth grade practice test questions because Smarter Balanced is no longer supporting testing in tenth grade.

I urge you to go to the practice and training tests and examine other items on other tests. The URL is www.smarterbalanced.org/practice-test. I assure you that you will find similar issues in the majority of items. In fact, you'll find them in virtually *all* of the questions that are not the old multiple-choice type.

Smarter Balanced's Promise to the Nation

Before going further, it is worth reviewing exactly what Smarter Balanced promised the nation when they submitted their proposal to the Education Department:

> *The Consortium is deeply committed to ensuring that the intellectual integrity and full rigor of the academic content standards are maintained throughout all forms of assessments developed to serve this system….*[25]

According to a January 2013 report from the National Center for Research on Evaluation, Standards, & Student Testing (CRESST), *On the Road to Assessing Deeper Learning: The Status of Smarter Balanced and PARCC Assessment Consortia*, Smarter Balanced makes these claims for assessing "deeper learning":

1. Concepts and Procedures: Students can explain and apply mathematical concepts and interpret and carry out mathematical procedures with precision and fluency.
2. Problem Solving: Students can solve a range of complex well-posed problems in pure and applied mathematics, making productive use of knowledge and problem solving strategies.
3. Communicating Reasoning: Students can clearly and precisely construct viable arguments to support their own reasoning and to critique the reasoning of others.
4. Modeling and Data Analysis: Students can analyze complex, real-world scenarios and can construct and use mathematical models to interpret and solve problems.[26]

The CRESST report came after the Measured Progress/ETS design guidelines were

released, but before anyone saw the actual test items developed by CTB. At that time, CRESST researchers were optimistic: "…a review of the task specifications and public release sample items suggest that Smarter Balanced performance tasks will be aligned with important goals for deeper learning…."[27]

They also cautioned, "However, at this early stage of test development, key questions remain about how well these intentions will be realized." And later, "…while technology-based assessment offers many new opportunities, care will need to be taken that the technology manipulation required by the assessment does not unintentionally add construct-irrelevant barriers for some students, particularly those with less access and less facility with technology."[28]

Contrast these promises to the reality of the delivered tests.

Flaws in the Smarter Balanced Test Items

What happened? Despite elaborate evidence-centered design frameworks[29] touted by Smarter Balanced as our assurance that their tests would measure up, the implementation of the tests is egregiously flawed. I wish I could say the flaws in the Smarter Balanced tests are isolated. Unfortunately, they are not. While the shortcomings are omnipresent and varied, they fall into categories, all illustrated multiple times by the examples in this critique:

- Poorly worded and ambiguous mathematical language and non-mathematical instructions;
- Incorrect and unconventional mathematical graphical representations;
- Inconsistent mathematical representations and user interfaces from problem to problem;
- Shoddy and illogical user interface design, especially with respect to the dynamic aspects of the mathematical representations;
- Consistent violations and lack of attention to the Common Core State Standards;
- Failure to take advantage of available technologies in problem design.

The result? Untold numbers of students and teachers in 17 Smarter Balanced states will be traumatized, stigmatized and unfairly penalized. And the quagmire of poor technological design, poor interaction design, and poor mathematics will hopelessly cloud the insights the tests might have given us into students' understanding of mathematics.

Technology-enhanced items could have made use of widely ratified and highly developed technologies (e.g., graphing calculators, dynamic geometry and data analysis tools) to engage students in substantive tasks. Instead, these tests rely on a small number of pedestrian and illogical interface "widgets"(arrays of checkboxes, crude drawing tools, graphical keypad, a drag-and-drop digit pilers, etc.) that the test item writers used via question templates. The widgets often provide window dressing for multiple-choice questions. Spending $330 million of federal spending could have funded real innovation—or at least deployment of the best technologies available for these tests. The public at large—students, parents, educators, policy makers—who see these poor and dated uses of technology may incorrectly conclude that technology can not significantly improve mathematics instruction. These tests give educational technology a bad name.

Soon after I circulated the first version of this critique, Elizabeth Willoughby, a fifth grade teacher in Clinton Township, MI, sent me the following note:

> *After reading your piece covering the flaws you found on the Smarter Balanced assessment, I had to reach out and thank you. I teach fifth grade. I put my students on the math test, made a video and sent it to Smarter Balanced. My students are on computers almost every day—they are tech savvy. The video is worth a watch: https://www.youtube.com/watch?v=UZgb46Jm4Oo.*

I watched Ms. Willoughby's video. You should, too. Her "tech savvy" kids are as confused by the test interface as I was. The video vividly demonstrates that even these very capable students will get stuck on the Smarter Balanced tests as a result of the shoddy interface.

Ms. Willoughby also shared with me her email exchange with the Smarter Balanced Help Desk on the subject of her students' problems. The email below is part of this exchange and occurred in March 2014:

> *…Reading below, you will see my students took the practice test and had many issues with the student interface. Smarter Balanced, in reply, sent me a series of confusing emails filled with half-information regarding access to TIDE and field tests which supposedly has updated tests with cleaner, easier to operate user interface tools… I would greatly appreciate an answer to a simple question:*
>
> > *Your email below acknowledges the issues with the student interface tools found on the practice tests. Your email also indicates you found the same issues in the recent field test. Your email below clearly indicates you will make changes to the practice test to address these issues…Can I get a general timeline as to when the update to the practice test will occur and will the practice test reflect all of the student interface skills students will need to perform tasks on the actual test? As these skills are unique to your assessment (not found in other programs, apps, etc.), your practice test needs to provide those practice opportunities.*
>
> *I don't mean to press, however, these ARE high stakes tests. I need to be prepared and I need to prepare my students for success on these tests, which includes providing them with the ability to use the assessment with success.*
>
> *Thanks, Elizabeth L. Willoughby*

Ms. Willoughby received no satisfactory reply. Despite vague assurances the iterative rounds of field tests would address her students' frustrations with the interface, we see that nothing has improved by the launch of the actual tests.

CTB created nearly 10,000 test items for Smarter Balanced[30]. If half of these are for mathematics, there are almost 5,000 items already deposited in the mathematics item bank. Bad items will surface on tests for years to come.

Liana Heitin, in a September 23, 2014, article in *Education Week*, "Will Common-Core Testing Platforms Impede Math Tasks?" wrote:

> *Some experts contend that forcing students to write a solution doesn't match the expectations of the common-core math standards, which ask students to model mathematics using diagrams, graphs, and flowcharts, among other means.*
>
> *"It's not like, during the year in classrooms, these kids are solving these problems on the computer," said David Foster, the executive director of the Morgan Hill, Calif.-*

based Silicon Valley Mathematics Initiative, which provides professional development for math teachers, creates assessments, and has worked with both consortia. "It's such an artificial idea that now it's test time, so you have to solve these problems on computers."

Mr. Foster, who has authored problems for the new Common Core tests, goes on in the article to say:

"I'm a mathematician, and I never solve problems by merely sitting at the keyboard. I have to take out paper and pencil and sketch and doodle and tinker around and draw charts," he said. "Of course, I use spreadsheets all the time, but I don't even start a spreadsheet until I know what I want to put in the cells.

"All Smarter Balanced and PARCC are going to look at is the final explanation that is written down," he said, "and if there's a flaw in the logic, there's no way to award kids for the work they really did and thought about."

Mr. Foster added: "I've played with the platform, and it makes me sick. And I've done it with problems I've written."

Further along we hear the same sentiment from another expert:

But, as James W. Pellegrino, a professor of education at the University of Illinois-Chicago who serves on the technical-advisory committees of both consortia, points out, students can solve a single problem in any number of ways, not all of which are easy to explain in words.

"The worry is [the platform] narrows the scope of what students can do, and the evidence they can provide about what they understand," he said. "That leads to questions about the validity of the inferences you can make about whether students really developed the knowledge and skills that are part of the common core."[31]

In a post to the Illinois Council of Teachers of Mathematics listserv in July 2014, Martin Gartzman, Executive Director of the Center for Elementary Mathematics and Science Education at the University of Chicago, took specific aim at the shortcomings of the PARCC tests, but also stated that his criticisms applied equally to Smarter Balanced:

I understand that creating a large-scale assessment, such as the PARCC assessment, is an incredibly complex task that involves many decisions and many compromises. However, I assert that we are being far too generous about PARCC's decision regarding the ways that students can enter their responses to open-response, hand-scored items. By accepting that decision, we are essentially endorsing an assessment system that, by design, does not give students a fair shot at showing what they know about mathematics, and that we know will underrepresent what Illinois students understand about the mathematics addressed in the CCSS-M.

This is not an issue of students needing to get used to the PARCC formats. The problem is that the test format itself is mathematically inadequate. The extensive PARCC field test definitively affirmed that the limited tools available to students (keyboard and equation editor) for entering their responses made it extremely difficult for many students to demonstrate what they knew about the CCSS-M content and practices.

While the experts cited here are highly critical, I think the actual situation with the new tests is even more disastrous than they describe. The tests suffer from the problems they

describe *and* the issues go far beyond the limitations imposed by computer keyboards and equation editors. The appalling craft displayed in these tests compounds the problems that even well-conceived computer-based mathematics tests would have to overcome to effectively assess students.

In July 2012, Measured Progress, a contractor to Smarter Balanced, warned in *Smarter Balanced Quality Assurance Approach Recommendation for the Smarter Balanced Assessment Consortium*:

> *In this industry and with a system of this highly visible nature, the effects of software that has not been sufficiently tested can lead to an array of problems during a test administration that can be financially and politically expensive.*[32]

Interestingly, my online review of the Smarter Balanced proposals and contract documents finds little evidence of attention to quality assurance at the level of "widget" or item development. There are vague statements about item review processes, but few specifics. There is a tacit assumption that the companies that develop high-stakes tests know how to develop mathematical test items and will do it well and that they are capable of performing their own quality assurance. Those of us in the education industry know better.

Unfortunately, the Smarter Balanced tests are lemons. They fail to meet acceptable standards of quality and performance, especially with respect to their technology-enhanced items. They should be withdrawn from the market before they precipitate a national catastrophe.

We know, however, that this won't happen. Test season has already started.

Kids Deserve Better

Struggling students will likely be penalized more than proficient students on the Smarter Balanced tests as the cognitive load of grappling with poorly designed interfaces and interactive elements will raise already high levels of test anxiety to even more distracting levels. Those who attempt to mine the test results for educational insight—teachers, administrators, parents, researchers, policy makers—will be unable to discern the extent to which poor results are a reflection of students' misunderstandings or a reflection of students' inability to express themselves due to difficulties using a computer keyboard or navigating poorly constructed questions and inadequate interactive design.

Time spent prepping for these tests using the practice and training tests and learning how to use the arcane test tools like the "Equation Response Editor tool" is educational time squandered. Many schools have scheduled inordinate numbers of days just for this test prep, but using the tools offered by Smarter Balanced will lead to none of the educational outcomes promised to support CCSSM. These tools are not learning tools that lead to mathematical insight, they're highly contrived force-a-square-peg-into-a-round-hole test-specific tools.

If widespread testing is going to be a reality in schools, and if schools are going to deploy scarce resources to support computer-based tests, then it is essential that tests successfully assess students and contribute more generally to the improvement of the quality of education. There is no good reason for the tests to be this bad. The past forty years of extraordinary progress in research-directed development of mathematics visualization and technology for expressing mathematical reasoning could be put to use

to power these tests—elegantly and effectively. As an example of computer-based assessment pursuing a vastly higher quality standard than that achieved by Smarter Balanced and CTB, look at the December 15, 2014, and January 5, 12, and 19, 2015, blog posts at *Sine of the Times*: http://blog.keycurriculum.com. These posts describe work we did some years ago at KCP Technologies and Key Curriculum Press. Others in the mathematics education community—researchers and practitioners—know how to do quality work.

"Déjà Vu All Over Again"

The results of the Smarter Balanced tests for 2014–2015, when they come, will further confuse the national debate about Common Core and contribute significantly to its demise. Because the general public has no reason to believe that these results do not accurately reflect mathematics education in this country, they will not realize that the poor performance of students on these tests is due, in significant part, to the poor craft of the test makers. When poor results make headlines, will anyone point the finger in the direction of the test makers? Likely not.[33] Students and frontline educators at all levels will be attacked as incompetent—but the incompetent test makers will get a free pass.

I've seen this before. Twenty-five years ago, Creative Publications, a California publisher, developed *MathLand*, an innovative elementary mathematics program. These materials were rated as "promising" by a U.S. Education Department panel. But Creative Publications had rushed the materials to market for the 1992 state of California adoption and *MathLand* was not ready for "prime time." However "promising," it was poorly crafted—ideas were not fully developed, there had been little or no field-testing, little revision of the original manuscript, and there had been no application of the iterative principles of product engineering. Even so, a majority of California school districts adopted *MathLand*. Why? Because it was a promising idea and the craft issues with *MathLand* were invisible to an untrained eye. And there was no pilot period during which schools and districts could properly vet the materials within the California adoption timeline and reject them if they proved lacking. Whatever one's position on the underlying educational principles of *MathLand*, the materials did not work well in classrooms—but no one found this out this until too late. Completely lost in the public uproar over *MathLand* was the distinction between good ideas and poor craft. As soon as they were able, California districts abandoned *MathLand*. Creative Publications disappeared. In California, the *MathLand* fiasco discredited California's 1992 Mathematics Framework and significantly contributed to the launch of the national "Math Wars." It has taken 20 years to undo the damage these poorly crafted materials did to our mathematics education community.

The Common Core State Standards for Mathematics and the high-stakes tests under development by Smarter Balanced and PARCC are not one and the same. However, in the public eye, and particularly in the crosshairs of Common Core political opponents, Common Core and the Smarter Balanced/PARCC high-stakes tests funded by the federal government are two sides of the same coin. As Diane Briars, National Council of Teachers of Mathematics (NCTM) President, pointed out in "Core Truths," a July 2014 "President's Corner" message: "Particularly problematic is a tendency to equate CCSSM with testing and with test-related activities and practices."[34]

While certainly not perfect, the Common Core State Standards for Mathematics are a step forward, especially because of the prominence of the Standards for Mathematical

Practice. I believe that CCSSM should continue to receive full support and that it should evolve and improve based on the experiences of practicing teachers, mathematics professionals, mathematics educators, parents, students, and a wide range of other stakeholders. In high-performing countries like Singapore and South Korea, national curricula are revised and improved on a regular schedule. South Korea, for instance, has revised its national curricula once every 5 to 7 years and is now using the 7th iteration of the curriculum.[35] However, the appalling Smarter Balanced high-stakes tests could well be the death of the national effort to improve mathematics instruction via Common Core—before we ever get to iteration 2. That would be tragic.

I don't think I'm alarmist. In a September 14, 2013, article in the *Atlanta Journal-Constitution,* titled "Errors plague testing in public schools: Consequences for students can be dire," Heather Vogell pointed out:

> *Quality-control breakdowns have become near commonplace on the state tests taken in public schools across the country, The Atlanta Journal-Constitution found. Faulty tests undermine reforms seeking to rescue American schools and risk harming them instead.*[36]

Ironically, while poor results on the Common Core tests will be a blow to policy makers, parents, educators, and students, they will be a boon to those in education for a profit. I've been in the business for decades as an educational publisher. For many companies, including the large ones, there is no business like the "failure business." Failure precipitates large-scale crises. National politicians, governors, and state legislatures demand immediate action to address crises. In desperation, school officials look for quick solutions. They loosen purse strings in states and districts. And quick-solution vendors spring into action, throw together products, and make money from their "solutions."

The same testing companies that delivered these failed tests will win new contracts to deliver "better" tests to states forced to abandon the current ones. Next year you'll see a host of new "Common Core" branded intervention and test prep programs pitched as solutions to a problem caused, in part, by the same companies who will be pitching the solutions. The large education companies with both testing and curriculum divisions make money on both ends.

What Can We Do?

The national testing train is hurtling down the tracks out of control. Fueled by lucrative contracts with testing companies, often driven by people with insufficient understanding of the educational and social consequences of their actions, and racing to reach a destination in too little time, the train will crash very soon.

What can one do? The boldest choice, and in some real sense, the most principled one, would be to jump off.

If I were a state administrator responsible for state testing, a superintendent, a school board member, a teacher, a parent, or even a student old enough to make my own decisions about my education, I would seriously consider not participating in the coming round of high-stakes national testing—the tests will do too much damage on too many levels to students, teachers, and champions of education. I salute those who have taken courageous stands to opt-out of the new rounds of testing. Flawed tests cannot be fixed in the time before they'll be administered. And in the current political climate, there will not be funding available for those who *could* fix them to *actually* fix them.

I recognize that a stand to resist the tests has many consequences, some severe in the short run. But anyone who takes this stand now will be exonerated in the long run. It is the moral *and* practical thing to do. Next year a stand taken against the tests today will look prescient.

I also recognize that most people with a stake in education aren't inclined or aren't in a position to become "conscientious objectors" and opt-out of participating in the coming tests. What can *we* do?

Since I wrote the first version of this critique, the California Board of Education decided to suspend its Academic Performance Index for the 2014-2015 school year, according to Christine Armario of the Associated Press, in order "to give teachers and students time to adjust to standardized tests aligned with the Common Core standards."[37] That action is a useful start to a process that must be much more ambitious if we want to put the assessment train back on the tracks. Students and teachers *do* need time to adjust to the higher expectations embodied in Common Core. But equally important, and not addressed in the California Board action, states need several more years, at least, to develop assessment systems worthy of the efforts that the teaching community is making to improve instruction. Until then, "accountability" ought to go on hold.

While I have looked in detail at the Smarter Balanced mathematics tests, many responsible educators cited above and elsewhere have called into question the efficacy of other high-stakes Common Core-aligned tests.[38,39] All states should take a "time out" to apply careful analysis to their high-stakes tests, including both the Smarter Balanced and PARCC tests, and question whether the new crop of tests will drive the improvements in educational outcomes they seek. Our educational professional organizations should participate in this analysis. The analysis should be complete and transparent.

We can mitigate the damage done by flawed tests by protecting students from days, weeks, even months of test prep for these tests. Based on the evidence Smarter Balance has given us, practice on their tools will not lead to better teaching or learning. In fact it will "dumb down" instruction.

We can urge schools and school boards to ignore the results of contrived and fatally flawed high-stakes tests like the Smarter Balanced tests—they do not measure mathematical understanding.

We can make sure that those responsible for flawed assessments—the state testing consortia and the testing companies they hired—fix the problems they have created. At the same time, the nation and our states must realize that outsourcing educational assessment to for-profit companies is not in the long-term public interest and will inevitably lead to low-quality systems out of sync with national priorities. In most countries, educational assessment systems are developed and maintained by well-funded national government agencies, accountable to the public, who draw upon the expertise of leading educators and professional bodies, not people hired anonymously on a per-contract basis to write test items.

We can support and defend the teachers and educational professionals who have done all they can to improve mathematics education in countless ways, but who will unfairly take the fall for poor test results.

We can work to uncouple the Common Core effort from poorly crafted tests and try to save the potential of CCSSM when politicians attack Common Core because of poor test results.

We can seek help from our professional teaching organizations like NCTM and the National Council of Supervisors of Mathematics (NCSM) to apply the organized collective wisdom of educational practitioners and mathematics education leaders to the task of accurately measuring student progress in attaining higher outcomes in mathematics. Those closest to classrooms and children are best able to see what works and doesn't in mathematics education. Our professional bodies represent the best thinking in our field.

We can continue to research and develop well-crafted digital tools for mathematics education and work to deploy them in realistic time frames and in appropriate contexts.

We can demand the education funding necessary for teaching and assessing in this country in ways worthy of our students. The promise of cheaper but deeper assessments[40] was a false promise from the start.

We need to back off the high-stakes testing craze that is destroying public education. Mathematics can be interesting and engaging. But the steady diet of boring test prep faux mathematics that we are force-feeding kids in our classrooms is robbing them of the opportunity to learn and teaching them to dislike a beautiful subject. And at the same time it is driving veteran teachers into retirement and discouraging bright young people from pursuing careers in education.

Maybe we can even make great assessments some day.

About Steven Rasmussen

Steven Rasmussen is an educational consultant at SR Education Associates. He was co-founder, publisher and president at Key Curriculum Press, a mathematics curriculum publishing company. As president of KCP Technologies, an educational software research and development company, he led teams that specialized in the development of dynamic digital tools for mathematics classrooms. These mathematics technologies have been adopted for state and national use—for both teaching and testing—by ministries of education in high-performing countries such as Canada, Singapore, and China.

Steve serves as an advisor and board member to various non-profit and for-profit organizations working in mathematics education. Steve has worked with ministries of education in numerous countries, especially in Asia, and has spoken frequently at international and national education conferences.

Please send comments to steve@mathedconsulting.com.

A Mathematical Aside: Looking at Question 5 from the Perspective of Calculus

If one steps back from the specifics of Question 5 and thinks more generally about the mathematics modeled by the problem and its answer space, in particular, looking at it from the perspective of calculus, one can't help being deeply concerned about it. The problem asks a question about a population that is represented by an area under a curve to the left of a movable vertical line. The curve, in this case, represents a normal distribution of the population. The area to the left of the line is an area-under-the-curve-left-of-the-line function with the *x*-value of the line as its independent variable. The range of this function is 0% to 100%. Depending on the value of this variable, as one moves in a small region around a particular point on the *x*-axis, the area function may be changing rapidly or barely changing at all. It may be changing at a relatively constant rate or changing at a varying rate. The bell curve *is* the rate of change of the function.

But the snap-to number line forces discrete and evenly spaced jumps on the *x*-axis (each jump equal to one inch of height) and forces us to seek an answer based on these jumps as if the function were varying at a constant rate over the entire domain. Across the domain of the function, a jump to an integer value of *x* may cause the output of the area function to change a lot—or barely at all—depending on the height of the bell curve at that point. At the points on the curve where the value is high, more accuracy is needed to predict specific outcomes because more change in area is taking place. Had the question asked for the place where approximately 1% of the women were shorter and 99% taller, there would many good answers to the question. In fact, if the number line extended all the way to zero, one could hop along the number line from integer to integer, starting at 0 and going all the way to 56, hardly changing the population left of the line, and keeping the population "approximately" 1%.

The test makers, by luck or by design, chose a value of the function (25%) where the normal distribution curve is nearly an integer and where the relatively straight bell curve allows accurate extrapolation of values, even though the area function is changing relatively quickly. Area functions defined by a normal distribution curve are fairly tame in their behavior. However, other area functions (i.e., definite integrals) based on other curves (i.e., functions) can be less well behaved. A small change in the value of the input to the function may cause the output to race to infinity, or go suddenly to zero—or both.

From the point of view of statistics education, Question 5 is a very poor question. From a more general mathematics perspective, it sacrifices good mathematical thinking and problem solving in the interest of concocting a test question with an integer as an answer. It encourages students to guess at ways to come up with their answers that have no applicability in more general cases. It is misleading, misguided, and, like so many others on these tests, fatally flawed.

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