THE REVENGE OF K-12: HOW COMMON CORE AND THE NEW SAT LOWER COLLEGE STANDARDS IN THE U.S.

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Executive Summary

It is now clear that the original promise to anchor K-12 education to higher education and backmap the Common Core Mathematics Standards (CCMS) from the upper grades down to the primary grades was empty rhetoric. Higher education has scarcely been involved at all, with the exception of the institutions that agreed to place high school students who pass a Common Core-based high school examination directly into credit-bearing freshman coursework (without remediation) in return for their states receiving "Race to the Top" grant funds.

Because the CCMS are standards for all public school students in this country, regardless of achievement level, they are low standards, topping out at about the level of a weak Algebra II course. And because this level is to determine "college readiness" as they define it (which is not remotely what our public four year college and universities currently assume it to be), it is apt to mean fewer high school students taking advanced mathematics and science coursework before they go to college, more college freshmen with even less knowledge of mathematics than currently, and more college credit-bearing courses set at an international level of seventh or eighth grade.

However, the greatest harm to higher education may accrue from the alignment of the SAT to Common Core's high school standards, converting the SAT from an adaptable test predictive of college work to an inflexible retrospective test aligned to and locking in a low level of mathematics. This means that future SAT scores will be less informative to college admission counselors than they now are, and that the SAT will lose its role in locating students with high STEM potential in high schools with weak mathematics and science instruction.

1. Introduction

Americans are currently barraged with sales pitches to support implementation of the Common Core Standards (CCS) in K-12 education. Protesting parents and other critics are demonized or ignored. Unprecedented sums of money are being spent to convince us that we must implement the CCS and the tests based on them because we need higher academic achievement to compete with other countries in a global economy. (And because Bill Gates and his foundation think the whole project is a good idea.)[1]

The assumption is that the CCS are overall more demanding than the standards most states had and or could maintain.[2] This report focuses on the CCS for secondary school mathematics because it is the gateway to careers in science, technology, engineering, and mathematics (STEM), not to mention computer science and economics. As we show, the Common Core Mathematics Standards (CCMS) are not equal in rigor to their international peers; in fact, they leave American students well behind them. Worse yet, the CCMS unambiguously *lower* standards in high school mathematics and, by implication, high school science.

The greatest damage to our educational system, however, may result from the conversion of a college admission test predictive of students' ability to do college-level work to one aligned to the CCMS's low expectations for secondary school mathematics.[3] Alignment of the SAT to the CCMS cements these lower expectations into place for the foreseeable future, degrading American education at both the secondary and college level.

This report spells out the dangerous effects of the CCMS on U.S. secondary and higher education. Colleges will be harmed in three ways by the alignment of the SAT (and other) college admission tests to the lower level of high school mathematics coursework set by the CCMS. First, the alignment of major college admission tests down to the level of the CCS cements the low CCMS high school standards in place for a long time. Second, SAT scores will become less informative to college admission directors as they are less correlated with *aptitude* for college work and more correlated with measures that are already available, such as high school grade-point average, class rank, state high school exit exams, and the new tests of the two Common Core testing consortia. Third, the SAT will abandon its role in locating students with high STEM potential in high schools with a weak mathematics and science curriculum.

This report also identifies the features of a high-quality testing system, long familiar to European and East Asian countries, but still unfamiliar to Americans.

II. How the Common Core Standards were Developed

A consistent deference to American higher education was prominent in the early sales pitches for the CCS. The CCS were to be built from "the top down," starting with standards at the upper secondary level that were appropriate and sufficient for preparing students for college-level work. Once those standards were agreed upon, work would commence on lower secondary standards appropriate and sufficient to prepare students for upper secondary work. After those standards were constructed, work would commence on middle grade standards appropriate and sufficient for preparing students for lower secondary work, and so on down to kindergarten.[4]

A second theme stressed in the early sales pitches was the importance of having "fewer, clearer, and deeper" standards. Anyone following education policy debates for the past 15 years would often have heard the expression "a mile wide and an inch deep." It was used to criticize U.S. mathematics standards and textbooks in K-12, and it served as one explanation for our relatively poor performance on international tests (although the information that served as the basis for comparing what is taught in high-performing countries with what is taught in this country came from the K-8 grades and not high school).[5]

High-performing countries do tend to have fewer standards per grade level than our states have had, but mostly in the lower grades. Elementary teachers in those countries spend more time with each standard, go deeper into key concepts, and guide students toward mastery of them. While there are a smaller number of CCMS in the lower grades than were in most U.S. state standards, there are even fewer CCMS in the upper grades. This is exactly opposite what is done in the high-performing countries. See the Appendix for the required topics of study in China's lower high school grades for a dramatic confirmation of this.

What education systems in high-achieving countries do is slim down the content in the early grades with a laser-sharp focus on key material, such as the introduction of ratios and motion at constant speed in grade 3 or 4 (at least two to three years earlier than in the U.S.). Then, taking advantage of the deeper grasp that those children have of the foundational material, later courses—Algebra in grades 7 and 8 and geometry in grades 8 and 9—easily cover the new material to a depth well beyond what we can usually manage.

In high-achieving countries, the focused development of the foundations of mathematics in the early grades is like the trunk of a tree, supporting ever-widening content in middle and high school. In contrast, the CCMS are more like a tube with reasonable expectations in the lower grades but no broadening in middle or high school. Instead of a base of K-5 mathematics knowledge and skills supporting a full canopy of mathematics and its applications in high school, the CCMS support only a few sickly branches. The writers of the CCMS used a structure that mostly makes sense for the early grades, but they continued to use it through middle and high school, where it does not make much sense at all.

But even with the right structure, there would still be problems with the CCMS in the lowest grades. Here is a standard for grade 1 that illustrates one of their failings:

> "NBT.4. Add within 100, including adding a two-digit number and a one-digit number,

> and adding a two-digit number and a multiple of 10, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used. Understand that in adding two-digit numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten."

This standard is actually the amalgamation of several standards that should have been kept separate. In high-achieving countries, only a small amount of what is in this standard is covered in grades 1 and 2. But that limited content alone takes up much of the instructional time in these grades.

Moreover, much of standard NBT.4 (for example, "relate the strategy to a written method and explain the reasoning used") is absurdly inappropriate to ask of children in grades 1 and 2. Also, the number of choices given, ("using concrete models or drawing and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction") is overwhelming for young students. If this standard was meant to demonstrate the "fewer, clearer, deeper" theme, it has failed badly, or maybe even catastrophically

One might argue that perhaps the writers of this standard wanted to list all possible methods a U.S. teacher might use to explain this topic, reflecting the reasoning that "any way one solves a math problem is as good as any other." But these wildly disparate approaches do not warrant equal stress. Only strategies based on place value are crucial to master for later studies.

In contrast, as noted above, the primary grade standards and textbooks in high-achieving countries are concise and slim. Just a few basic principles are stressed. More important, mathematical advice is followed for selecting both the core elements and the way textbooks approach them. For example, in high-achieving countries like Singapore, Korea, Japan, Hong Kong, Belgium (Flemish-speaking), and the Czech Republic, addition is a key topic but not subtraction. Students learn that subtraction is defined in terms of addition: e.g., "A - B is that number C so that when B is added to C we get A." Moreover, students learn how to use the definition to find C when asked. This approach is accessible to children and emphasizes what matters mathematically. Whereas in high-achieving countries educators attempt to "simplify, simplify, simplify" and "focus, focus, focus," U.S. educators tend to exhibit a radical egalitarianism toward standards and methods: it is deemed inappropriate to label any one method as superior or inferior to others, so all must be included and given equal weight.[6]

As a result of a simplified focus, students in high-achieving countries learn a relatively small amount of mathematics by grade 5 or 6, but what they learn is the foundational material that supports their mathematical learning for the rest of their school days: what whole numbers and fractions are; how to add and multiply them, and consequently how to subtract and divide them; and finally, how to place them on the number line. They also learn about measurement, ratios, rates, and proportions, and they can solve complex problems involving these topics. They know this material so thoroughly that they will never need to visit it again. Then, based on this carefully developed foundation, they can and do branch out in the higher grades.

The required standards for lower secondary school in China (in the Appendix) far exceed the material CCMS provides for U.S. students in all high school grades. The picture that one should have of the mathematics curriculum in high-achieving countries is that of a tree with a carefully and fully developed trunk supporting a massive canopy.

Several years before development of the Common Core State Standards Initiative (CCSSI), Achieve, Inc. (an education policy organization directed by business executives and the governors of the 50 states) completed the American Diploma Project (ADP).[7] ADP's high school exit standards were intended to lay out the minimal entry requirements for colleges and industry for high school graduates, with the expectation that schools and states participating in the project would make this content the baseline for what would be covered. When CCSSI began, the CCMS for high school were modeled on ADP's high school exit standards, although the CCMS became more prescriptive as they evolved through several drafts.

The ADP standards were of two types, un-starred and starred. Topics that the writers thought every student needed were un-starred, while the starred items

> "…represent content that is recommended for all students, but is required for those students who plan to take calculus in college, a requisite for mathematics and many mathematics-intensive majors."

Likewise, the CCMS have two types of standards: unmarked and those marked with a (+). The unmarked standards are again for all students, but the (+) standards are now described as "additional mathematics that students should learn in order to take advanced courses such as calculus, advanced statistics, or discrete mathematics." The "must learn" in the ADP standards was weakened to "should learn" in the CCMS, with the implication that these "advanced courses" are too difficult for all but the most advanced students.

This has profound implications for high school course offerings. Indeed, the CCMS go on to read: "All standards without a (+) symbol should be in the common mathematics curriculum for all college and career ready students." *In other words, they are all that college-going students really need.*

The CCMS ended up as a political compromise. The document was designed to look attractive to both education schools and content experts. However, in mathematics, these are mostly incompatible objectives.

Start with a look at the table of contents at the top of the next column.

The standards break into four incoherent parts:

1. **"Mathematical Practice"** consists of three pages designed to attract those whose misunderstanding of mathematics launched the "math wars" a quarter-century ago after release of the first

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(later revised) version of the National Council of Teachers of Mathematics (NCTM) 1989 mathematics standards.[8] This 258-page document claimed to overview what mathematics is. It didn't.

"Mathematical Practice" was included in the CCMS document against the advice of many mathematics professors and should be universally ignored. In practice, too many educators focus on them to the exclusion of the actual mathematics standards. As a result, the CCMS are often interpreted as re-creating the old 1989 NCTM Standards even though most of those involved in mathematics education had come to believe the controversy over the 1989 standards was settled many years ago. The NCTM document had met catastrophic failure after significantly lowering outcomes in every state that attempted a more-or-less faithful implementation. California is a good example. The NCTM standards were adopted there in 1992. By 1996 the resulting problems had become so acute that a rebellion led by parents and the state's high tech industries forced the state to create new standards.[9]

But, those nostalgic for the original NCTM standards can wave the CCMS' "Mathematical Practice" as evidence that they have been exonerated. In many cases, in staff, test, or curriculum development, these three pages are the only part of the CCMS that is used.[10] Indeed, many authors and even witnesses at state hearings on Common Core have commented that these three pages are often shown to educators with the explanation that "these *are* the Common Core Mathematics Standards."[11]

"Fuzzy math" programs such as *Investigations (in Number, Data, and Space)*, *Everyday Math, Core Plus, Connected Mathematics Project* (CMP), *College Preparatory Mathematics* (CPM), and *Interactive Mathematics Project* (IMP), produced dismal results (these programs had been implemented in the vast majority of California school systems by 1995 or 1996) and parental reaction removed them from the school curriculum, particularly in California. Authors of these programs adamantly oppose the teaching of the standard algorithms, including those for long multiplication and division, and discourage memorization of basic number facts (e.g., the multiplication table). Instead, students are made dependent on calculators and mental crutches such as fraction strips and finger counting.[12] Despite their abundant failures, these programs are now resurfacing based on current interpretations of CCMS.

According to Common Core's David Coleman:

> "There are two types of people in math in my judgment. There are the kind of groovy, understanding people, and then there are the mean, rote people."[13]

Are CCS proponents lurching us toward a repetition of the math wars? Below is an example of how interpreting the CCMS through the prism of Mathematical Practice works out in practice. From a grade 4 Common Core-aligned worksheet:[14]

Crates	Boxes	Bundles	Envelopes	Packets	Loose
2	35	?	?	?	?

Explain it! If you have 2 crates and 35 boxes,
how many bookmarks do you have altogether?
Explain your thinking.

What is so disturbing about the example above is that every problem that can be solved mathematically must be "well posed." This means, in particular, that it can only have one acceptable solution. But this problem is not well posed. There is no way of deciding "How many bookmarks" from the data given. We are not told how many bookmarks are contained in a crate or a box, or even if every box or crate has the same number of bookmarks as any other box or crate. Thus, the correct answer to this question must be "Any number is possible." Indeed, the student whose mother showed this example to us claimed the answer was over 100,000.

Questions like this undermine one of the chief uses of training in mathematics—the recognition and need for precision in both verbal statements and individual thinking.

2. In **Kindergarten through Grade 7**, the standards specify key topics students need to learn to be prepared for basic uses of mathematics in everyday life. They are mostly well written, although they are also pedagogically prescriptive. For example, in the development of fractions in the elementary grades, we find detailed descriptions of the pedagogy for presenting them – not just as suggestions, but as parts of the standards themselves.

Particular strengths include fractions, basic geometry, place-value notation, and standard algorithms (although their development is one to two years behind the expectations of high-achieving countries). Particular weaknesses include ratios, rates, percentages, preparation for abstraction, and Algebra.

Overall, the K-7 standards in these grades are better than 90 percent of previous state standards. They are nearly as good as the old California, Indiana, and Massachusetts standards in Kindergarten through grade 5. (This remark is not meant as praise for CCMS. Rather, it is a reflection of the abysmal quality of the vast majority of the previous state standards.)

3. In **Grade 8**, the rigor of the standards declines markedly. Apparently, requiring completion of Algebra I in grade 8 was deemed unacceptable. So grade 8 mostly marks time and does a tiny bit of Algebra around the equations of lines in the plane. It also begins a strange development of geometry that is very close to an approach tested in the former Soviet Union in the late 1970's and early 1980's. That approach was rapidly abandoned and there is virtually no research to support it, certainly not for large-scale implementation. In both middle and high school geometry, students are to use only rotations, translations, and reflections to justify and, in a few cases, even prove results.[15]

4. In **Grades 9-12**, the strange development of geometry continues but now includes some topics seldom taught in a first-year geometry sequence, such as the three trigonometry standards (G-SRT6 to G-SRT8) that usually appear in a course on trigonometry, and the (+) standards G-SRT9 to G-SRT11 that are normally covered without proofs in geometry and proved early in a trigonometry course or in Algebra II. The standards for circles (G-C1 to G-C5) are challenging, to say the least, to say nothing of G-GPE1 to G-GPE7, which are for conic sections and proving basic geometry in the coordinate plane.

While the standards for an Algebra I course are mostly complete, the standards for Algebra II are weak overall, despite inclusion of the small amount of trigonometry often developed in Algebra II. Then the slow-moving train simply stops.

In the end, the progression of standards was ad hoc—not in any particular order. "College and career readiness" may have been a guiding principle. But, it was college and career readiness as inconsistently defined by self-appointed education policy groups and perhaps the standards writers themselves. No directly relevant groups (parents, high school mathematics teachers, or college teaching faculty in mathematics, science, and engineering or leaders in high tech industry) were involved.

Nor was the CCSSI-appointed Validation Committee (VC) a force to be reckoned with. Although the Validation Committee's original charge was to review the work of the standards writers, evaluate its quality as well as the degree to which the standards were research-based, and either demand additional work or declare CCS valid, this charge was severely weakened in the end. Moreover, the committee included four non-U.S. citizens (an Australian, Englishman, German, and Taiwanese), and R. James Milgram was the only mathematician on the VC and the only member with a Ph.D. from outside a school of education.

The VC had originally been charged with adding a standard it deemed missing provided it supplied evidence (1) that the standard was essential to college and career success and (2) that the standard was internationally comparable. Milgram used this charge to increase the college readiness level (in the first CCMS draft) from Algebra I to (a weak) Algebra II, but he could not get it increased further. Shortly after this, the VC was stripped of the power to demand changes in the drafts. In the end, committee members could only sign or refuse to sign a letter affirming that the CCS were research-based and internationally benchmarked. The letter was signed by 24 of the final 29 members.[16]

III. Who Wrote the Common Core Mathematics Standards?

We begin with the "lead" writers for both sets of standards because some of the chief writers of the English language arts standards are connected to some of the chief writers of the mathematics standards. The three "lead" writers of Common Core's English language arts (ELA) standards were David Coleman, Susan Pimentel, and James Patterson. The three "lead" writers of Common Core's mathematics standards were Jason Zimba, William McCallum, and Phil Daro.

David Coleman majored in classical philosophy as an undergraduate, and earned a master's degree in classical philosophy from Cambridge University in England. He worked at McKinsey and Company before beginning a business with Jason Zimba in the mid-2000s called Student Assessment Partners. He had no teaching experience in K-12 or above. Speaking at the Institute for Learning at the University of Pittsburgh in 2011, he acknowledged: “We’re composed of that collection of unqualified people who were involved in developing the common standards.”[17] He also claimed: “…I probably spend a little more time on literacy because as weak as my qualifications are there, in math they’re even more desperate in their lacking.” Coleman is now president of the College Board.

James Patterson was and remains a staff member of ACT specializing in the language arts. He majored in journalism as an undergraduate and taught at the secondary school level.

Pimentel majored in early childhood education, earned a law degree, and served as the chief consultant to Achieve, Inc. on the American Diploma Project (ADP). In 2007, Pimentel helped develop “backmapped” standards from grade 4 on for ADP’s high school exit ELA standards. Pimentel’s other standards-writing experiences include work as a consultant to StandardsWork on the Texas 2008 ELA standards (with Sandra Stotsky) and, in the 1990s, to California on its ELA standards (with Sheila Byrd Carmichael, Carol Jago, and others with experience as English teachers). Pimentel’s teaching experience had been in a Head Start program.

Both Pimentel and McCallum may have been selected to be standards writers by Achieve, Inc. McCallum, a mathematics professor at the University of Arizona (with a Ph.D. in mathematics), had also served in 2007 as a consultant to Achieve, Inc. while it was developing backmapped standards for ADP’s high school exit mathematics standards. McCallum’s experience with standards writing prior to 2009 consisted almost exclusively of his work on this unfinished project.

The second Common Core mathematics standards writer, Jason Zimba, had never written K-12 standards before or studied the standards of high-achieving countries so far as we know. Zimba was a physics and mathematics professor at Bennington College (with a Ph.D. in the mathematical sciences) at the time he was writing the CCMS (he has since retired), and had previously worked with David Coleman at Student Assessment Partners. Both he and Coleman were likely selected to be standards writers by the Bill & Melinda Gates Foundation.

The third lead author of the CCMS was Phil Daro, a staff member at the National Center for Education and the Economy (NCEE), headed by Marc Tucker, a member of Common Core’s reviewing group and a recipient of several Gates Foundation grants. Daro had majored in English as an undergraduate and his mathematical background appears to have consisted entirely of a short stint teaching middle school mathematics.

In 2009 or before, Daro chaired a NCEE committee tasked with determining the minimal amount of mathematics students need in order to be college and career ready. The final report, released in May 2013, concluded that an Algebra I course was all that was necessary.[18] Since community colleges were the sole focus of the report, its conclusion is relevant only to readiness for community colleges, not four-year state or private colleges and universities. What influence Daro (or Marc Tucker) had on Common Core’s college readiness level in mathematics in 2009 is unknown (no records are available), but the NCEE report makes it clear that the kind of college to which college and career readiness standards were applicable *was intended to be a community college*.

Indeed, the two authors of the CCMS, Zimba and McCallum, are on record as publicly acknowledging the limitations of the middle and high school standards.[19] In January 2010, when referring to the first public draft of the mathematics standards for college readiness (released in September 2009), McCallum stated:

> “It’s not what we aspire to for our children. It’s not what we as a nation want to set as a final deliverable. I completely agree with that, and we should go beyond that.”

While the final document (released in June 2010) covers topics in Algebra II and geometry, coverage remains so minimal that Jason Zimba could state at a public meeting in Massachusetts in March 2010, referring to what seemed to be the final version: "The minimally college-ready student is a student who passed Algebra II" (i.e., no trigonometry, pre-calculus, or calculus, as in high-achieving countries). And he judged the CCMS as "not for STEM" and "not for selective colleges."

At this meeting, after Zimba clarified the meaning and implications of the Algebra II college readiness expectation in CCMS, he also mentioned "the third pathway," a pathway to calculus. Indeed, that March draft contained place-markers (see below) for the main topics in a high school calculus course:

Limits and Continuity	F-LC
Differential Calculus	F-DC
Applications of Derivatives	F-AD
Integral Calculus	F-IC
Applications of Integration	F-AI
Infinite Series	F-IS

Although the March draft did not contain the material in trigonometry and pre-calculus that should be taught after the Algebra II topics (where the March draft ended) and before the calculus material indicated by the place-markers, readers of the March draft could reasonably assume that the standards writers planned to put this crucial material in, thus creating the "third pathway." But the final version of CCMS from June 2010 ends with Algebra II, no third pathway was worked out, and the place-markers are gone. To this day we do not know why the CCMS lack a pathway to calculus, despite the implications this has for the STEM pipeline and the U.S. economy. Nor do we know who was responsible for removing the place-markers and for the decision to leave the third pathway out.

iv. Common Core-Based K-11 Mathematics Tests—No Child Left Behind Ensconced

Common Core advertising can be confusing, and not just because every phrase is saturated with flattering adjectives, but also because the vocabulary used to describe the standards has different meanings in "educationese" than it does in Standard English. One day we hear that the CCS are higher, richer, deeper, tougher, and more rigorous[20] and will rationalize a confusing panoply of several dozen sets of state standards. The next day we hear—in response to state and local complaints about a perceived overwhelming effect—that changes should be imperceptible as they are just standards or, as Hector Barbossa said in reference to the Pirate Code, they're "more what you would call guidelines than actual rules."[21] Most definitely, advocates insist, the CCS are not a curriculum; each teacher in each classroom will be completely free without constraints to teach in his or her own way. (Yet, presumably, the end result—what students learn—will still be validly comparable across all tests across the country.)

That is true as far as it goes. Ultimately, it is the tests and the stakes attached to them, not the standards, which affect change, for better or worse. After the CCS were developed, the United States Department of Education (US ED) funded two consortia to develop tests based on them: the Partnership for Assessment of Readiness for College and Careers (PARCC) and the Smarter Balanced Assessment Consortium (SBAC).[22]

Will the types of tests and test items they develop be superior to what we have had? It is too soon to know because final versions of these tests have not yet been given. But we do know about the dismal results from their key predecessors—the allegedly higher-order, more authentic, performance-based tests administered in Maryland (MSPAP), California (CLAS), and Kentucky (KIRIS) in the 1990s.

Those testing programs failed because of unreliable scores; volatile test score trends; secrecy of items and forms; an absence of individual scores in some cases; individuals being judged on group work in some cases; large expenditures of time; inconsistent (and some improper) test preparation procedures from school to school; inconsistent grading on open-ended response test items; long delays between administration and release of scores; little feedback for students; and no substantial evidence after several years that education had improved. As one should expect, instruction had changed as test proponents desired, but without empirical gains or perceived improvement in student achievement. Parents, politicians, and measurement professionals alike overwhelmingly rejected these dysfunctional tests.[23]

Resounding public distaste killed those programs. But 20 years is a long time in the ever-"innovating" world of U.S. education policy, long enough for those new to education policy to be unaware of the earlier fiascos. Indeed, many of the same individuals and organizations responsible for the doomed New Standards Project that inspired the disasters in California, Kentucky, and Maryland in the 1990s have been central to developing and promoting the CCS. (The New Standards Project was co-directed by Mark Tucker's NCEE and Lauren Resnick's Institute for Learning at the University of Pittsburgh.)

Pilot or transition tests for PARCC and SBAC have already elicited parents' anger across the country. Teacher feedback from a December 2013 field test of SBAC in Nashua, New Hampshire corroborated their reaction. Middle school teachers gave their principal anonymous feedback on their reactions. Fairgrounds Middle School (FMS) Principal John Nelson reported publicly that: "The FMS staff collectively believe that the Smarter Balance Test is inappropriate for our students at this time and that the results from this test will not measure the academic achievement of our students; but will be a test of computer skills and students' abilities to endure through a cumbersome task."[24]

Below are two sample mathematics problems released by SBAC, both intended for the Algebra exam. In the first example, the problem is not well posed. The correct answer is that n can be anything you want it to be. Thus, A, B, C, and D are all correct, at least for n greater than 6.

Use the chart below to answer question 4.

Input	3	4	5	6	. . .	n
Output	10	13	16	19	. . .	?

4. If the input is n, what will the output be?

A. $n + 3$
B. $n + 7$
C. $3(n + 2) + 1$
D. $3n + 1$

The hidden assumption here is that the first several values of a function completely determine the function for all values. This is absolutely not true. The remaining values can vary in a wide variety of possible ways. If an engineer were to use the kind of argument implicit in the problem above to say that a certain polynomial, for example, gives the forces at a key joint in a bridge, there could well be enormous problems. As almost always happens, the actual force function is far more complex and it is almost never the case that a polynomial is a good approximation. As a result, the bridge specifications could well have critical errors, leading to terrible consequences.

It should be understood that, these days, too many people in the U.S. look at a problem like the one above and say "It seems fine to me." However, this is really a symptom of the vast decline in the mathematical and scientific literacy of our society.

After all, one of the key roles of mathematics instruction is to promote critical and precise thinking in analyzing and solving problems. The all-too-common response to questions like the one above should be regarded as a huge hint as to why more and more of our technical jobs are being taken by non-U.S. citizens and, all too often, are simply being exported to one of the high-achieving countries. Engineers who would accept a question like this as reasonable are not the people we really want programming our computers or designing and giving the specifications for our buildings.

The second example has little to do with mathematics. Rather, it is about some relatively arbitrary conventions that are often used to minimize the number of parentheses in an arithmetic expression. What students need to know is that the division sign in this example means that before doing anything else they are to divide 3 by 3.

> The steps Quentin took to evaluate the expression $3m - 3 \div 3$ when $m = 8$ are shown below.
>
> $$3m - 3 \div 3 \text{ when } m = 8$$
> $$3 \times 8 = 24$$
> $$24 - 3 = 21$$
> $$21 \div 3 = 7$$
>
> What should Quentin have done differently in order to evaluate the expression?
>
> A. divided (24 – 3) by (24 × 3)
> B. divided (24 – 3) by (24 – 3)
> C. subtracted (3 ÷ 3) from 24
> D. subtracted 3 from (24 ÷ 3)

By contrast, here is a typical problem taken from a grade 6, high-stakes Japanese national exam from the mid 1990's. The expected time to solve it is two minutes:

> A train (traveling at constant speed)[25] crossed over a 970-meter long bridge in 95 seconds. The same train took 60 seconds to pass through a 480-meter long tunnel.
>
> *How long is this train?*
>
> *A. 180 meters*
>
> *B. 360 meters*
>
> *C. 480 meters*
>
> *D. 520 meters*
>
> *E. 580 meters*

It is probably safe to say that most grade 8 students in this country would not be able to solve this problem at all, let alone in two minutes.

Succeeding the 1990s disasters of MSPAP, CLAS, and KIRIS, was the No Child Left Behind Act (NCLB), initiated with bipartisan support in 2001, but now lovelorn, with few public defenders. Despite what many seem to be assuming, however, CCS-aligned tests will neither replace nor significantly alter the unloved No Child Left Behind Act's assessment program.[26] The CCS merely changes the content base from which the NCLB assessments draw. Indeed, one might say that CCS reinforces - even rigidifies - the structure of NCLB as it continues the assessment system.

Indeed, the CCS-aligned assessments will "fix" only one aspect of the assessment system created under NCLB—comparability of student scores across states—not one of the most important problems and one for which we already had a workable solution.

According to the sales pitch for the CCS, aside from "strengthening the STEM pipeline," the chief reason for the CCS and the assessments based on them is comparability of student achievement across states. Many policy makers and education researchers were frustrated with NCLB's delegation of student testing to the states. Each state could decide on the kind of tests to give and on the score to represent "proficiency." The proportion of students deemed "proficient" thus varied from state to state. To address the variation, states were required to participate every two years in the tests given by the National Assessment of Educational Progress (NAEP). Changes in average scores in grades 4 and 8 and in the percentages in NAEP's four performance categories could serve to show student growth (and state/school/teacher effort). Discrepancy ratings (a comparison of the percentages in NAEP's four performance categories with the percentages in these categories on state assessments) also showed how rigorous a state test was. Scores from stratified random samples of students could be, and were already being, compared across states.

If the comparability promised by CCS-aligned assessments comes to pass with uniform national performance standards, we already know one general result. States that tend to score poorly on national tests—generally poorer and more southerly states—will produce relatively small proportions of "proficient" students and relatively larger numbers of schools needing to be restructured. States that tend to score well on national tests—generally richer and more northerly states—will produce relatively large proportions of proficient students.

v. Common Core-Based College Admission Testing—The Degradation of the SAT

Consider the irony in the College Board's decision to hire as its president someone without a doctoral degree in any discipline or any experience in testing and measurement: David Coleman, the principal writer of Common Core's ELA standards.[27,28]

On March 5, 2014, Coleman announced planned changes in the Mathematics SAT.[29] He explained that there would be three areas of focus: problem solving and data analysis (which will include ratios and percentages and other mathematical reasoning used to solve problems in the real world); the "heart of Algebra" (which will test how well students can work with linear equations "a powerful set of tools that echo throughout many fields of study"); and what will be called the "passport to advanced math" (which will focus on the student's familiarity with complex equations and their applications in science and social science). We do not yet know exactly what these changes will look like, but it is worth noting that the promised changes in the Mathematics SAT appear to be close to what the 1989 and 2000 NCTM standards were asking for, a move away from assessing mathematical skills and techniques to assessing ideas *about* mathematics from a philosophical perspective.[30]

Prior to Coleman's arrival, competent and experienced testing experts suffused the College Board's staff. But, rather than rely on them, Coleman appointed Cyndie Schmeiser, previously president of rival ACT's education division, as College Board's Director of Assessments.[31] Schmeiser brought along her own non-psychometric advisors to supervise the College Board's psychometric staff.[32] While an executive at ACT, Schmeiser aided Coleman's early standards-production effort from 2008–2010 by loaning him full-time ACT standards writers. (It should be no surprise, then, that many of the "college readiness" measures and conventions for CCS-aligned tests sound exactly like ACT's.)

Ironically, even while ACT criticized low U.S. education standards during Schmeiser's tenure, the company steadily lowered standards for its flagship product, the ACT college admission test. In contrast to test administrations 20 years ago, current students taking the ACT more than once can choose which session's scores will be sent off to college; and scores are no longer flagged when tests are administered with accommodations.

Since Coleman and Schmeiser arrived at College Board, they have adopted other ACT innovations, namely: elimination of the penalty for guessing, and making the writing test optional.

The key driver of growth in ACT testing over the past decade, however, has been statewide administration of the ACT. Several states now administer the ACT to all of their high school juniors and seniors. There are benefits for the states. Some high schoolers who had not planned on applying to college change their minds after receiving a surprisingly high ACT test score. But, the benefits to ACT are even greater. The state pays the student test fee, and the state's schools administer the test, saving ACT enormous effort and expense. In contrast, the SAT and the ACT in other states are administered in controlled, highly secure environments by SAT or ACT proctors.[33]

The ACT test's competitor, the SAT, began as an acronym for "Scholastic Aptitude Test." The original SAT was developed in the late 1930s to give students from less socially and financially advantaged backgrounds a chance to show their eligibility for this country's most demanding institutions of higher learning. James B. Conant, President of Harvard College, and others encouraged development of such a test to find "diamonds in the rough"—students with high academic potential who did not come from well-to-do or socially connected families and had not been exposed to the fine arts, other cultures through travel, libraries filled with great literature, or advanced science and mathematics coursework in their public high schools.

Arguably, the chief problem with aptitude testing is its name and the resentment that spawns. To some, "aptitude" implies a genetic inheritance or native intelligence–an intellectual superiority that some people simply have and others don't. It sounds unfair and undemocratic. Some critics argue that achievement tests promote equality of opportunity and aptitude tests stifle it. The stigma is unfortunate and stymies better understanding and wider use of a useful psychometric tool.[34]

The key difference between achievement and aptitude tests has nothing to do with native intelligence. Achievement tests are retrospective, they measure knowledge already learned, whereas aptitude tests are predictive, measuring readiness for future activities. A high-quality achievement test is highly aligned with a curriculum students have taken and validated by how well it summarizes the student's accumulated knowledge. Such a test might be entirely appropriate for college admission if college coursework were just like high school coursework. But, it's not.[35]

A high-quality predictive test is highly aligned with desirable future outcomes and validated by the correlation between test performance and those outcomes—predictive validity. Predictive tests are widely used in business, industry, and government when organizations wish to estimate how well new employees will perform in new situations.

The best predictive tests are perfected over time. In the beginning, one incorporates the best available expertise for an initial version that represents a best guess at prediction. Then one tests the test by administering it, either in field tests or actual operational administrations. Afterwards, one calculates the correlation of individual test items with the desired outcomes. Highly correlated items will be used again; poorly correlated items will be tossed, and replaced by new draft items ready for try-out.

If one were to try to replicate from scratch what other countries with more successful education systems do – *require high quality retrospective achievement tests for secondary school exit and separate, predictive tests for university entrance* – how would one do it? One would develop a best-guess initial test with items intended to be retrospective and others intended to be predictive, and try it out on a representative student population. Afterwards, the items highly correlated with the mastery of the school curriculum would be kept in one pile and items most predictive of future success kept in another. Poorly correlated items would be tossed. Then, one would write more items and run the process again.

Ultimately, the test items in the two piles would be different, but probably not entirely. Some good retrospective test items can also be highly predictive. The retrospective test would have items highly aligned with the past curriculum and focused on measuring mastery of content and skills. The predictive test would demand less mastery of content and instead include "common knowledge" facts or present commonplace situations in order to measure one's readiness to acquire new knowledge or skills or reason through problems. Predictive tests are sometimes called "readiness" or "reasoning" tests.[36]

The key differences between retrospective and predictive tests for college admission are:

- Predictive tests can be periodically adjusted to optimize their predictive validity (tossing poorly predictive test items and drafting new ones); retrospective tests are less flexible—their test items must cover the high school content domain, whether or not they are predictive. Further, in the case of the major test consortia for the Common Core Standards, the PARCC and SBAC, they are required to test the material listed in the non-plus standards, but are not allowed to test the material in the CC (+) standards, which almost certainly have more to do with college readiness than the non-plus standards.

- Considering all the information about applicants available to college admission counselors, predictive tests tell them more. A retrospective test covering the high school curriculum largely duplicates information in other available measures, such as the high school grade point average (GPA) and class ranking

- A predictive test can identify a unique population of students who can succeed in college but who otherwise would not go to college, or would enroll in postsecondary programs that do not tap their full potential. This population of students includes those who may be:
    - bored by the rigidity of a particular high school curriculum but who nonetheless learn much on their own by studying what interests them;
    - not well adapted to the social environment of a particular high school but who may be comfortable with the social environment of a college; or
    - of high ability or motivation but enrolled in a dysfunctional high school.

  This population can be rather sizeable, but it is not organized and has no lobbying power. Indeed, most students in this population do not even know that they belong to it.

With a new CCS-aligned SAT, we come full circle. Those who have criticized the SAT as socio-economically biased still do not understand that retrospective achievement tests, even if academically less demanding, strengthen instead of weaken the influence of parents' income and education.[37,38] Perfection over time will not be possible with a CCS-aligned SAT even after the new tests are administered several times, the test items are analyzed, and it is discovered, as is inevitable, that some of them are not predictive. The College Board will be stuck with a limited test that they will be powerless to improve.

With a predictive test, one would toss the non-predictive items—as they are providing no useful information—and try out some new ones. With an aligned SAT, thorough, representative coverage of the CCS standards will be necessary to maintain alignment. Test items representing all the standards must remain, whether or not they predict anything useful. The available test item set for a CCS-aligned SAT will remain basically static, even after the new, lower predictive validity of the test becomes known.

David Coleman also hinted at possible changes in the Advanced Placement (AP) exams when he announced planned changes in the Mathematics SAT in March 2014.[39] They would, first, be aligned with the CCMS and, second, be changed in emphasis in the direction of more "problem solving." We currently have no information on the details.

VI. How Many Purposes Can a College Admission Test Serve?

Those promoting the new SAT do not concede that it will be less predictive, but they assert that it will be aligned to the alleged high, "rigorous" standards of the Common Core. In fact, the two goals are, to a large extent, mutually exclusive.

A test consultant's promise to address multiple measurement needs with a single measurement instrument can be quite tempting to policy makers. Such a measurement instrument saves time and money and reduces disruption. But what happened in Chile can serve as a warning.[40,41]

Prior to 2002, higher education institutions in Chile employed a predictive test modeled on the College Board's SAT for college admission, the *Prueba de Aptitud Académica* (PAA). Some faculty in some disciplines (e.g., engineering) added their own specialized content tests to admission requirements, but most relied on PAA scores and high school grades to evaluate applicants. Chile's system was not unlike what one found in most of the United States at that time: most students taking the SAT and some students taking one or more Advanced Placement (AP) tests or SAT achievement tests in their best subjects.

Then, in 2000, a small group of academics, with no testing experts among them, proposed replacing the PAA with a test that could also monitor the implementation of a new high school curriculum.

Called the *Prueba de Selección Universitaria* (PSU),[42] in a typically Panglossian way it was described simultaneously as a high school exit test, as a university entrance examination, as a way to monitor implementation of the new high school curriculum, and as a way to increase opportunities for students from low socioeconomic backgrounds.[43] Authorities in Chile and at the World Bank also argued that the test would fairly measure mastery of two very different national curricula, incentivize high schools to implement the new curriculum, incentivize high school students to study more, predict success in university generally, and predict success across very different types of university programs.

The PSU was sold as a test that could do anything one might like a test to do, but it actually does nothing well.[44] In fact, the PSU is a retrospective achievement test that covers only one of Chile's two high school curricula, but it is not used as a high school exit exam (if it were, the majority of students would not graduate). Instead, it is used as a university entrance exam, although its predictive validity coefficients are much lower than those for the current ACT or SAT in the United States[45] and, so far as we can tell from a single study,[46] much lower than those for the prior Chilean exams, the PAA and associated subject tests.[47]

The 40 percent of Chilean high school students who follow the vocational-technical track stand almost no chance of succeeding on the PSU; they are not even exposed to the last two years of the curriculum it covers. (Moreover, in some rural areas, the vocational-technical track is the only one available.) Unlike current SAT and ACT exams, the content base of the PSU is very specific and coachable, advantaging wealthier parents who can pay to have their children coached. Over time, the PSU score disparity across socio-economic groups has widened.[48] Children of wealthier parents have taken places in elite universities that once were available to poorer students with good grades and potential.[49]

With audits and evaluations bringing only bad news,[50] the Council of Rectors, the group of university heads responsible for the PSU, has closed ranks. The effect is that an assessment program with little transparency grows ever-thicker walls around its "black box."[51] Unfortunately, the PSU will continue to be used for the foreseeable future.

The Chilean college admission system seems to work well for well-to-do parents—their children arrive in the primary grades ready for school, attend private schools with advanced curricula, follow the college track (the *científico-humanista* track) in high school, and receive four full years of that curriculum. The PSU is less than ideal for the majority of students—students who follow the vocational-technical track in high school, or start from behind in the early grades, or never see all four years of the college-track curriculum in high school.

VII. Features of High-Quality Testing Systems

The best testing systems, such as those in many European and East Asian countries, are multi-level and multi-targeted. A multi-level testing system administers tests at more than one educational level (i.e., primary, intermediate, lower secondary, and upper secondary). European and Asian students typically face high-stakes tests at the beginning or the end (or both) of at least two educational levels.[52]

A multi-target testing system gives every student, regardless of achievement level or choice of curriculum, a high-stakes test with a challenging but attainable goal. In some systems, tests are set at differing levels of difficulty related to different certifications (e.g., a "regular" diploma and an "honors" diploma). In other systems, tests cover different subject matter. For example, the French *baccalauréat*–the secondary level exit exam for their academic track–is subdivided, first by three *séries* (literature, economics and social science, science) and then, by *spécialités*, *options*, and *travaux personnel encadrés* (personal project work). Ultimately, one French student might take just one from among a spectrum of dozens of possible exit exams, as well as a completely different higher education entrance exam from among variety of them.

In the United States, high-stakes tests for students are uncommon at any but the high school level. Moreover, with few exceptions, they are single-target tests—meaning that every student, regardless of achievement level, course selection, curricular preference, or school quality must meet the same standard of performance to pass.

Ironically, European and East Asian societies with smaller disparities in income and academic achievement than the U.S. have acknowledged their children's differences by offering a range of academic options and achievement targets.[53] The U.S. has for decades been pushing most children[54] toward the same path—college—and is now setting a single academic achievement target.

A single academic achievement target must of necessity be low, otherwise, politically unacceptable numbers of students will fail. School systems with low targets have typically concentrated on bringing the lowest-achieving students up to the target level. Unfortunately, average- and high-achieving students are apt to be neglected or deliberately held back. Schools judged on overall student performance can increase average scores, for instance, either by retaining high-achieving students with their age-level peers rather than letting them advance a grade or by making these same students take courses in subject matter they have already mastered. These artificially restrained students all too often lose motivation, suffer from extreme boredom, act out, and/or drop out.[55]

The single-target problem has two solutions, one passive and one active. The passive solution lets individual students take a minimum-competency test early in their school careers; once they pass it they are allowed to move on.[56] If the test is high stakes only for individual students, then no one has an incentive to hold higher-achieving students back, that is, to prevent them from taking accelerated coursework afterward, based solely on the test results.

The active solution to the single-target problem, and the solution that promises greater overall benefits, is to offer multiple targets. New York stands out historically as the one state that employed a multiple-target examination system, with a Regents "Competency" exam required for high school graduation with a "regular" diploma, and a Regents "Honors" exam required for graduation with an "honors" diploma.[57]

European and East Asian testing systems reflect their educational programs. Students are differentiated by curricular emphasis and achievement level, and so are their high-stakes examinations. Differentiation, which starts at the lower secondary or middle school level in many countries, exists in virtually all of them by the upper-secondary level. Students attend schools with vastly different orientations: advanced academic schools to prepare for university, general schools for the working world or for advanced technical training, and vocational-technical schools for direct entry into the skilled trades. Typically, all three types of school require exit tests for a diploma.

Supporters of the one-size-fits-all U.S. system often label European and East Asian education systems as "elitist" and our system as a more "democratic," "second chance" system. That contrast may have been valid 60 years ago but is no longer. It is now easier to enter upper-academic levels in current European systems, and most countries now offer bridge programs for, say, a dissatisfied vocational-track graduate to enter a university or an advanced technical program. Typically, bridge programs are free of charge.[58]

Our public education system is neither less elitist nor more conducive to "second chances." In typical European or East Asian systems, multiple programs and tracks offer multiple opportunities for students to attain high achievement in something. A student in a "dual system" country who enters a vocational-technical program at the lower-secondary level and finishes by passing the industry-guild certification examination as a machinist enters an elite of the world's most skilled and highly remunerated crafts persons. By contrast, a high school student in a career-technical program in the United States may be perceived as attending a "dumping ground" school and may receive only low-quality training with out-of-date equipment. The typical solution to problems with secondary-level vocational-technical training in the dual system countries has been continuous improvement; the solution in most states is to pass off responsibility to community colleges.

Lip service was paid in the early days of selling CCS to a sequence of standards for career-technical programs.[59] In the final CCS documents, however, the word "career" appears only with "college," as in "college and career readiness." Any original intention with respect to curricular diversity, in this case to technical/occupational standards for career readiness, was abandoned as career readiness was assumed to be equivalent to readiness for college, but without clear evidence to support the equivalence.

The best examination systems make sense as integrated wholes. To be fair to all students, a testing system should offer opportunities and incentives to all students, and students are not all the same.

viii. Test Development and Accountability in Other Countries

Test requirements in the No Child Left Behind (NCLB) Act—mostly retained in the Race to the Top (RttT), SBAC, and PARCC initiatives—impose consequences on schools or school districts for low *student* scores. For U.S. students, already among the least stressed in the world, NCLB made school life even easier. Because the testing component of NCLB included no consequences for students, the message sent to them was that they need not work very hard. In this way, the largest potential benefit of testing—increased student motivation to work to pass the test—never accrued.[60]

When schools are held accountable for students' test performance, classroom teachers and school administrators, who should be the major supporters of a testing program, are put into the demeaning position of cajoling students to cooperate. *Such a dynamic is virtually unheard of in other countries where, unambiguously, it is the students who are tested and held accountable, not their teachers*.

For example, the *abitur*, the exit test for German academic high schools, consists of test questions submitted by subject area teachers and university professors every year. Teachers also take part in scoring the test. Indeed, one of the arguments for adding constructed-response test items (i.e., open-ended essay questions) to high-stakes state tests in the U.S. was the opportunity for further involving teachers in the testing process in addition to having them serve on test item review committees during test development.[61] Perhaps holding students accountable for their own test performance is what lies behind the fact that when students in high-achieving countries do not score as well as they expect, they say it is because they did not work hard enough. U.S. students tend to blame their teachers for poor scores instead.[62]

The origin of the U.S. focus on making *teachers* accountable for student test scores appears to lie with education researchers.[63] There is no reason to disbelieve the researchers' primary assertion: of the within-school factors that are quantified and available in the databases they analyze, teacher quality has the single largest effect on student achievement. The illogical leap to fallacy occurs something like this: education policymakers cannot control or, at least, have no direct control over what happens outside the schoolhouse door. They should focus their scarce resources on the factors they can influence, and those are the "within-school" factors.

Note that students are not generally considered "within-school" factors. After all, their legal guardians live at home; school officials only have them on loan several hours each weekday for about nine months a year. Nonetheless, students are sentient, willful creatures with agendas of their own who bring a lot of baggage with them from home to school. That baggage and their wills have more control over their performance—which is the performance being measured on the tests—than teachers do. Applying stakes to the test-takers has a more direct and stronger motivating effect on student achievement. The stakes need not be very high to be effective, but there must be some.[64] Who knows how well students try to perform on state NCLB tests?

The two testing consortia, PARCC and SBAC, are designing tests covering a mathematics sequence that tops out with a weak Algebra II course. In most countries, prospective university students must pass a retrospective achievement test to obtain a high school diploma and then sit for a completely separate university entrance test. In many countries each university administers its own entrance exam or leaves it up to each of its discipline-based departments to administer its own entrance exam (see Table 1). The original College Board and SAT tests were efforts to facilitate the process for potential applicants: instead of traveling and sitting for different college entrance exams, they could sit for just one test each and send their scores to multiple colleges.

Other advanced countries that require both high-stakes retrospective secondary school exit exams and separate high-stakes predictive college entrance exams include the Czech Republic, Denmark, Iceland, Korea, and the Netherlands. Southeast Asian countries include Brunei, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, and Vietnam.[65]

Then there is Finland. Testing critics have encouraged us to examine its education and testing system, learn from it, and copy it.[66] Why look at Korea, Japan, China, Singapore, the Netherlands, or other countries with strong testing and accountability programs that tend to score consistently high on a variety of international assessments when one can instead focus on the single anomalous country with an apparently mild testing and accountability program that scored highly just once on just one international assessment and, otherwise, tends to score below the world average?

Finnish students excelled on a single administration of the Programme for International Student Assessment (PISA), a test of low middle school mathematics skills given to 15-year olds. PISA de-emphasizes the fundamentals of mathematics in favor of routine examples of "mathematical literacy" from everyday life and has been characterized by U.S. mathematicians as "shopping cart" math, and criticized by Finnish mathematicians for the misleading signal it gave of Finnish students' mathematical performance. Finland's scores on more recent PISA tests have declined.[67] Its students have scored consistently lower on the more mathematics-intensive Trends in International Mathematics and Science Study (TIMSS).[68]

Until the Bill & Melinda Gates Foundation and the US ED open their minds to a wider pool of information sources and more intellectual diversity, they will continue to produce education policy white elephants.[69] It is unfortunate that the designers of CCS did not investigate what other countries with better functioning education systems do, beyond the single aspect of content standards.

IX. Effects of the Common Core Mathematics Standards on Grades 9-12

The important thing to keep in mind is that the CCMS fall apart at the high school level. A weak Algebra II course is dreadful preparation for college for three reasons.

First, the Algebra material in the CCMS is minimal, with neither logarithms nor conic sections adequately covered to say nothing of the analysis of rational functions and preparation for the partial fraction decomposition of rational functions. All are standard high school topics in a traditional Algebra II course, and are essential for STEM and related majors in college.

Second, even if the Algebra II course were stronger, the likelihood of a high school student with courses in geometry, Algebra I, and Algebra II finishing a four-year college degree program is low.

Table 1. Requirements for Admission to Higher Education, by Method and Country

	Completion of secondary/ degree or certificate	Upper secondary exit exam	Separate entrance exam	Additional course work	Experience	Academic standards	Late or re-entry options for adults and dropouts
Australia	■	□	■		●	■	Yes
Canada	■	□	●	□			Yes
France	■	■	●	●		■	Yes
Germany	●	■	●		●		Yes
Italy	■	■				■	Yes
Japan	■	■	■ ●				Yes
Russia	●		●			■	Yes
Spain	■		■	■		■	
Sweden	■	■	●		●	■	Yes
Switzerland	■	□	■		●		
United Kingdom	■	■	●			■	Yes
United States	□	□	○			○	Yes

■ Uniform national requirement; □ Only some jurisdictions require; ● Each institution has its own exams or requirements; ○ Only some institutions require

SOURCE: updated from Phelps, et al., *Higher education: An international perspective*, chapter 2. http://nonpartisaneducation.org/Review/Resources/IntlHigherEducation.htm

At an absolute minimum these college-intending students need to take an extra mathematics course in 12th grade. However, the poor preparation that the existing CCMS type courses provide will not be sufficient for students to get far enough in these extra courses to make up for the deficiencies in their previous instruction. It is important here to remember that the hierarchical nature of mathematics implies that incomplete courses in lower grades will always haunt students and their teachers in higher grades. Table 2 correlates the highest mathematics course taken in high school with the percentage of those obtaining a four-year college degree.

Clifford Adelman found that *the highest level of mathematics course taken in high school is the single strongest predictor of success in college, stronger than socioeconomic status, high school grade point average, or college admission test scores.*[71]

Table 2 shows that for students whose highest high school mathematics course was Algebra I, only 7 percent obtained a four-year degree in 1992. Table 2 also shows that for the class of 1982, a student who entered college with only Algebra II had a 46 percent chance of obtaining a four-year degree. For the class of 1992, this probability dropped to 39 percent. We estimate that the odds for the class of 2012 will be about 31 percent-33 percent due to larger numbers of students taking Algebra II and the weakening of high school mathematics coursework due to course title inflation and the adoption of CCMS. Algebra II was already becoming an increasingly lower standard for college preparation and will continue to decline.

Third, defining college readiness as mastering weak Algebra II content disadvantages students whose school districts do not have high socio-economic status. Table 3 shows that the availability of advanced mathematics courses is strongly related to the socio-economic status (SES) of the school district the student attends. A student attending a high school in the lowest SES quintile has only three/fifths the likelihood of access to calculus when compared with a student in the highest SES quintile; the data are similar for trigonometry and statistics. *But if the math required in high school stops with Algebra II because of CCMS, the numbers in Table 3 will only get worse.*

The CCMS cover only part of a standard Algebra II course, but the two test consortia, PARCC and SBAC, constrained by their alignment to CCMS, will include only that much Algebra. And because the newly revised SAT will be aligned to these low standards, it follows that fewer and fewer high schools will have any incentive to provide mathematics courses beyond this material.

A story from Mountain View, a town in Silicon Valley in California, puts this situation into real-life terms. Victoria Hobel-Schultz, a former attorney for the City of San Francisco, describes a relatively affluent suburb before the state required access to Algebra I for all students in grade 8.[72]

"In my community, there are two K-8 districts that join to attend a single high school district (9-12). One of the districts has a low-income Hispanic population. Before the state required that every student be offered Algebra I, very, very few Hispanic students were offered the opportunity in grade 8 (and very few in grade 9 took Algebra

Table 2. Relationship of Bachelor's Degree Attainment to Highest Level of High School Mathematics Coursework in 1982 and 1992

Level of math	Class of 1982		Class of 1992	
	Percent reaching this level of math	Earned bachelor's degree	Percent reaching this level of math	Earned bachelor's degree
Calculus	5.2	82.1	9.7	83.3
Pre-calculus	4.8	75.9	10.8	74.6
Trigonometry	9.3	64.7	12.1	60.0
Algebra 2	24.6	46.4	30.0	39.3
Geometry	16.3	31.0	14.2	16.7
Algebra 1	21.8	13.4	16.5	7.0
Pre-algebra	18.0	5.4	6.7	3.9

SOURCE: C. Adelman, *The Tool Box Revisited*, Table 5, p. 62.[70]

I, and just a very few of those passed the course.) In one year (2002), only one Hispanic student was ready for geometry in the ninth grade. The great majority of Hispanic students were offered "general math" and never transitioned to University of California math requirements.

> "When I went public showing that there were pockets of Hispanic students across the state learning math (e.g., Inglewood) and achieving high test scores, I was vilified. People in the community, especially the administration, publicly blamed ethnicity and family wealth for low academic achievement, not the district's instructional program. We were able to make some changes, but without the state adopting new math standards with standards-aligned instructional materials and tests, I doubt that any amount of advocacy would have been effective."

In about 90 percent of the states, given current implementation policies, there will be little if any coursework beyond the Common Core—only the most elementary parts of trigonometry, no pre-calculus content, and no calculus coursework at all. In theory, a local school district could keep these advanced courses, but in practice they most likely will not. Particularly in the lowest SES districts—where financial pressure to cut under-subscribed and unrequired courses is greatest—they will either be axed right off, or will disappear as soon as their lead teachers retire or leave. All that will be required for graduation is CCMS-based course work. That is all that is needed for entry into credit-bearing (i.e., not remedial) college math courses at the higher education institutions that participated in applications for Race to the Top grants.

The end of the CCMS mathematics sequence at the level of a weak Algebra II course will firmly squeeze the U.S. STEM pipeline. Data from the National Center for Education Statistics indicates that only 2 percent *of STEM-intending students* whose first college course is pre-calculus or lower ever graduate with a major in STEM areas today.[73]

The CCMS are not for the top 30 percent of high school students, but for the "average" ones. In California currently and historically, the top 30 percent of each high school graduating class is guaranteed admission to the State University of California system, while the top 10 percent is guaranteed admission to the University of California system. Both systems are selective, and the CCMS will not prepare students for either

Table 3. Relationship of Availability of Coursework in Statistics, Trigonometry, or Calculus to School District's Socio-Economic Status for High School Graduates in 1992

School district's socio-economic status	Percent attending high schools that offered…		
	Calculus	Trigonometry	Statistics
Highest quintile	71.6	83.1	34.0
Second highest quintile	56.2	73.2	27.1
Middle quintile	54.1	71.4	24.9
Second lowest quintile	49.3	70.3	20.3
Lowest quintile	43.5	63.7	18.5

SOURCES: National Center for Education Statistics: NELS:88/94 (NCES 96-130), and NELS:88/2000 Postsecondary Transcript Files (NCES 2003-402) of these systems. We believe this estimate to be conservative. Only 40–45 percent of high school graduates that enter college attend non-selective or community colleges. So the majority of high school graduates will be less than minimally ready for a regular four-year college or university.

What can we expect for results in our high schools? Because CCMS-aligned SAT and ACT tests will cover, at best, only the first two years of a high school curriculum (that is as far as the CCMS go, despite all the misleading rhetoric about how advanced they are), they will incentivize our students to learn nothing beyond what is in a junior-high-school level curriculum in high-functioning education systems. Indeed, the CCMS tests will encourage our high schools to spend four years teaching students what is taught in two years—and by grade 9—in the educations systems of our economic competitors. As we have seen, two of the three CCMS lead writers have publicly admitted the college readiness level is "minimal."

What will happen with the most academically talented students? Our expectation is that they will regress toward the mean, and we will lose a significant portion of them to mediocrity. The data seem to indicate that this will be especially true for students with academic potential from low socio-economic school districts.

x. Effects of the Common Core Mathematics Standards on Higher Education

The proposed top-to-bottom progression of standards writing, it was claimed, was part of a larger goal of the CCS movement: to fix our underperforming K–12-education system by shaping it to serve our first-class higher education system in mathematics and science. Actually, the reality is far closer to the exact opposite: the CCS and the assessments based on them now seem intended to reshape our first-class higher education system in mathematics, the sciences, and engineering to serve an underperforming K-12 system."

After the CCS had been written, one of the two CCS-based testing consortia, PARCC, publicized an effort to include some higher education officials in test development and implementation.[74] According to PARCC's chairman, Mitchell Chester, "The PARCC Governing Board has made a commitment to work with a broad group of stakeholders…" But, the higher education representatives were chosen by the PARCC board, making it too easy to pick like-minded people instead of broadening the board's expertise.

The CCS assessment and evaluation system as a whole does not even remotely resemble those of the world's best education systems. PARCC and SBAC are mostly building replacements for the NCLB tests, which will be administered under the same rules and conventions as current NCLB tests (but at several more grade levels). Scores on SBAC and PARCC high school examinations, however, will also be used to determine "college readiness," as they define it. As currently proposed, those who achieve a score that statistically predicts a 75 percent probability of achieving at least a "C" in beginning college Algebra or introductory statistics at a two-year college will be designated "college ready".[75]

Are the PARCC and SBAC high school examinations needed for this purpose? Arguably not, as there already exist national community-college level admission tests—COMPASS (ACT), and ACCUPLACER (College Board). PARCC and SBAC are using hundreds of millions of dollars of public funds to re-create the wheel and displace solutions that had already been developed (and extensively tested and refined) in the private sector. The "college readiness" measure based on SBAC and PARCC high school tests will be graded on a 1 to 5 scale, with a "4" (sound familiar?) representing a pass out of remedial coursework.

The College Board is converting the SAT into a secondary school exit exam, but it will be used, inappropriately, as a college entrance exam. The U.S. seems to be preparing to replicate Chile's illogical and dysfunctional assessment system.

When states applied for a Race to the Top grant, they agreed to a stipulation that state institutions of higher education "exempt from remedial courses and place into credit bearing college courses students who meet the consortium-adopted achievement standard for those assessments."[76] (These stipulations have been carried over into the PARCC and SBAC rules and regulations.)

In other words, the many higher education administrators who agreed to participate in their state's application for RttT funds relinquished their prerogative to place in remedial courses admitted students who have passed a Common Core-based high school test. That agreement has been expanded to include all public two- and four-year institutions in PARCC and SBAC consortia states.[77] The PARCC "college ready" target courses are beginning college Algebra or introductory statistics at a two- or four-year college, ***courses that students in high-achieving countries take in middle school***.[78] The CCMS-based assessment can replace the colleges' own placement exams, or currently available commercial exams (e.g., COMPASS, ACCUPLACER). A failed K–12 system for which the CCS were developed will determine the standards of entry to our currently internationally dominant higher education system in mathematics and science.

Moreover, once the SAT's alignment to the CCMS is completed, we can declare the end of aptitude testing in college admissions.[79]

Is the end of an SAT designed specifically to be predictive of college work a good thing? Emphatically no. Aligning the SAT to the CCMS will lower its predictive validity—because it will be less correlated with college outcomes.[80] It will also lower its "incremental predictive validity"—the proportion of the prediction estimate unique to the SAT (after all other factors are controlled)—because it will be more correlated with other measures already available to college admission officers, state high school exit exams, and the new "college ready" estimate from SBAC or PARCC.

Clearly, the new SAT will reduce the amount of useful information the College Board provides colleges. Aligning the college admission test to the CCMS will decrease its correlation with *real* college work. This means less information for matching student abilities to colleges' missions and resources. Moreover, students will bear the consequences when schools do not teach the CCMS adequately or sufficiently. Furthermore, students in private schools and states choosing not to adopt the CCMS may be disadvantaged by a CCMS-aligned SAT.

Finally, a CCMS-aligned SAT will diminish opportunities for a substantial population of students that would benefit from a less retrospective and more predictive test, especially academically able low-income students attending high schools with inadequate math and science curriculum and instruction.

XI. Conclusions

There are many extremely serious issues with the Common Core Standards (CCS) including their very low academic level and their poorly written and very confusing individual standards. Many people think that they represent a federal intrusion into the constitutional prerogatives of the states regarding K-12 education. But the most serious may be none of these. The one feature of the CCS that may cause the most harm to our education system is their singularity.

The frequent assertion that the CCS are internationally benchmarked misleads. The education systems of most of the highest-achieving countries—our economic competitors— have one aspect in common: multiple sets of secondary standards, or "pathways". Just a few states excepted, our country does not. Most European and East Asian countries have much smaller disparities in income and narrower "achievement gaps" across demographic groups than we have in the U.S. Nevertheless, by high school and in some countries by middle school, they provide for differences in curriculum preferences, in academic achievement, and in long-term goals.

From the perspective of a radical egalitarian philosophy, allowing secondary students to choose among different academic pathways is wrong because they won't all experience the same curriculum. Allowing the most academically advanced students to learn at their own pace would be unfair to their peers, it is implied. And allowing secondary students to choose among different occupational training programs or apprenticeships instead of taking a college-oriented program is also wrong according to this philosophy because not all students will be prepared to become doctors, engineers, or scientists.

Although lip service was paid to building career-tech and advanced "pathways" in the development of the CCS, only a single set of standards was finally offered for the PARCC and SBAC high school tests in the final version for both ELA and mathematics. Accordingly, all students are to be educated by age-based grade levels in a slow-moving train on a single track heading to colleges with low standards. *When there is just one set of standards*, standards, test items, and pass scores must be low enough to avoid having a politically unacceptable number of students fail.

Moreover, higher education institutions signing on to their state's Race to the Top application had to agree to place all high school students they accept who have passed a Common Core-based college readiness test directly into credit-bearing courses, i.e., *without remediation*. Many of these students will fail in current credit-bearing courses for freshmen until those courses, too, are watered down.

By providing only a single set of standards for college readiness, the CCS do not address the needs of at least the top 30 percent of our students. The CCMS effectively end at a weak version of Algebra II, defined as sufficient to make students "college and career ready." Unless our high schools provide the coursework they need, mathematically capable students will no longer be able to prepare for careers in science, technology, engineering, and mathematics (STEM).

While the CCS initiative lowers standards for advanced students in all grades, it will harm one group of students the most: low-income students with high academic potential. High schools with predominantly low-income students will likely drop their advanced mathematics and science courses, leaving low-income students with high academic potential without the opportunity to take these courses.

These students will also be harmed by the conversion of the SAT from a predictive (aptitude) test to a retrospective (achievement) test. Such a conversion makes it more susceptible to coaching and tutoring. This means, as we saw in the case of Chile, that high-income parents will be able to buy greater access to demanding colleges and ultimately to higher-paying jobs for their children. Conversion of the SAT test from a test validated by its predictive quality—its alignment to knowledge and skills useful in college—to a test validated by its retrospective quality—its alignment to the level of CCS-determined high school coursework—also means that the SAT will entirely lose its ability to find the "diamonds in the rough"—students with high academic potential in high schools with a weak mathematics and science curriculum.

PARCC and SBAC, the two testing consortia, are not developing assessment systems that will look like those in the world's highest-performing school systems. To a certain extent their tests will resemble some tests other countries use for some of their students. But, even so, they are not being developed the way that high-performing countries develop tests.

If the SAT and ACT developers stubbornly continue down their current (and we believe) unfortunate paths, lowering test administration standards and reducing predictive validity, colleges serious about maintaining high academic standards could well re-create a group like the original College Entrance Examination Board[81]—run by higher education institutions to serve higher education institutions—to sponsor the development of a predictive college admission test that enlightened institutions may use in place of the SAT and ACT examinations they will want to drop. This new organization could issue a request for proposals with the overarching goal "to develop a test with the highest predictive validity attainable." There should be no shortage of bidders; many large test developers, with expertise in large-scale educational testing, predictive testing, or both, are capable of challenging the SAT and ACT duopoly with a superior alternative.

If we seriously wish to emulate countries with high-performing education systems, we must consider more than just a single secondary curriculum track and a single testing target. High-performing countries offer their students a wide variety of curricular choices and tests, at different educational levels, and with different targets. Our students, too, have different goals and interests. It is long past time that we recognized that.

About the Authors

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Appendix: Chinese Mathematics Standards for Lower Secondary School

Below are the compulsory lower secondary school mathematics standards for all students in China. The final two pages sketch out the more advanced optional material for Chinese students interested in further study. The required standards for lower secondary school mathematics coursework comprise 5 modules.

Comparing these standards and, above all, the kinds of applications indicated here with what is asked for in CCMS will enable readers to better understand the vast differences between CCMS and international expectations. They will then understand the concerns about the economic consequences of our country's adoption of CCMS.

Perhaps the scariest of all of these courses is *Mathematics 3:Preliminary algorithms, statistics, probability*, and in that course, the material of *Part 1: Elementary Algorithm*. What is actually going on there is the development of basic computer programming, but not in the way typically done in the United States – learning how to use the Excel interface for example– but at the level of actual programming languages such as C+. The focus is on what really happens in the general process of using computers to study and/or solve basic types of problems where they can be helpful, but where standard programs such as EXEL are not programmed to do it. This is the kind of fundamental material that should have been included in CCMS. It is what "twenty first century mathematics" really is, and students in China and other high achieving countries will be able to use it, but there is little chance that students here will.

Mathematics 1: Set, concept of function, and basic elementary function I (exponential function, logarithmic function, power function)

1. Set Theory (about 4 class hours)

(1) Meanings of a set and its representation

- (i) Through real examples, familiarize with the meanings of a set, realize the "belong to" relationship between an element and a set.

(2) Basic relationships between sets

- (i) Understand the meanings of inclusion and equality between sets, identify subsets of a given set.
- (ii) Be familiar with the meanings of universe and empty set.

(3) Basic operations on sets

- (i) Understand the meanings of union and intersection of two sets, able to find the union and intersection of two simple sets.
- (ii) Understand the meanings of complementary set of a subset of a given set, able to find the complementary set of a given subset.
- (iii) Able to use Venn diagram to represent set relationships and operations, realize the function of intuitionistic diagrams to the understanding of abstract concepts.

2. Concepts of Functions and Basic Elementary Functions I (about 32 class hours)

(1) Functions

- (i) correspondences, able to find the domain and range of some simple functions, concepts of mappings.
- (ii) choose appropriate methods to represent functions (graphical method, tabulation method, analytic method) in accordance with the needs.
- (iii) Through concrete real examples, familiarize with simple step functions, and apply them.

(iv) Using functions already taught, particularly quadratic functions, comprehend the monotone characteristics of functions, maximum (minimum) values and their geometrical meanings; using concrete functions familiarize with the meanings of odd/even characteristics.

(v) Learn how to use graphs of functions to comprehend and study properties of functions.

(2) Exponential functions

(i) Through concrete examples (e.g. fission of cells, decay of 14C in archaeology, quantitative changes of residues of medicine left behind in human bodies), familiarize with the practical background of exponential function model.

(ii) Comprehend the meanings of rational exponent; through concrete real examples familiarize with the meanings of real exponent, and master the operations of power.

(iii) Understand the concepts and meanings of exponential functions, able to borrow calculators and computers to draw the graph of concrete exponential functions, explore and understand the monotone characteristics and special points of exponential functions.

(iv) Realize that exponential function is an important kind of mathematical models during the process of solving simple practical problems.

(3) Logarithmic functions

(i) Comprehend concepts of logarithms and the properties of their operations, know how to use the "change of base" formulae to convert general logarithms into natural logarithms or common logarithms; through reading familiarize with the history of the discovery of logarithm, as well as its contribution to the simplification of calculations.

(ii) Through concrete real examples, familiarize with the intuitive quantitative relationships depicted by models of logarithmic functions, begin to understand concepts of logarithmic functions, realize that logarithmic function is an important kind of mathematical model, able to borrow calculators and computers to draw the graph of concrete logarithmic functions, explore and understand the monotone characteristics and special points of exponential functions.

(iii) Know that exponential function y = ax and logarithmic function y = loga x are inverse functions of each other (a > 0, a not equal to 1).

(4) Power functions. Through concrete examples, familiar with concepts of power functions; using graphs of $y = x$, $y = x^2$, $y = 1/x$, $y = x^{1/2}$, familiarize with the behavior of changes of these graphs.

(5) Functions and equations

(i) Taking the graph of a quadratic function into account, decide whether the roots of a quadratic equation exist, and if so the number of the roots, so as to familiarize with the connection of zeros of a function with roots of an equation.

(ii) In accordance with the graph of a concrete function, able to borrow a calculator to use bisection method to evaluate the approximate solutions of the corresponding graph, familiar with the use of this common method to arrive at the approximate solutions of an equation.

(6) Modeling using functions and their applications

(i) Using computational tools to compare the differences in terms of growth and increments amongst exponential functions, logarithmic functions, and power functions. Using real examples realize the meanings of different kinds of growth and increments in mathematical modeling using functions, e.g.

rise in a linear manner, exponential explosion, and logarithmic growth.

(ii) Collect real examples of some commonly used models involving functions in everyday living (exponential functions, logarithmic functions, power functions, and segmentation functions), familiarize with the widespread application of modeling using functions.

Mathematics 2: Preliminary solid geometry, preliminary plane analytic geometry

1. Elementary Solid Geometry (about 18 class hours)

(1) Geometrical objects in space

(i) Use models of real objects and computer software to observe a large quantity of spatial figures; know structure characteristics of cylinders, cones, frustum and solid spheres and their simple constellation, as well as to use these characteristics to describe the structure of simple objects in realistic everyday living.

(ii) Able to draw three-view drawings of simple figures and objects in space (cuboids, solid spheres, cylinders, cones, prisms and their combinations); able to identify the solid models represented by the above-mentioned three-view drawings; able to use materials (e.g. cardboards) to make models; able to use "oblique method" to draw their intuitionistic diagrams.

(iii) Through observation, use two types of methods (parallel projection, central projection) to draw the three views and the intuitionistic diagrams; familiarize with the different ways of representation of figures in space.

(iv) Complete a practical assignment, such as draw the three views and the intuitionistic diagrams of some architecture (there is no rigorous requirement on size and type of lines subject to the condition that characteristics of the figures are not affected).

(v) Familiarize with the formulae for calculating the surface area and volume of solid sphere, prism, pyramid, and frustum (there is no need to memorize the formulae).

(2) Positional relationships amongst points, lines and planes.

(i) Borrowing models of cuboids, abstract definitions of the positional relationships of lines and planes in space based on the foundation of knowing intuitively and comprehending the positional relationships of points, lines and planes. Also, familiarize with the following axioms and theorems that can be used as bases for inferences.

* Axiom 1: If two points of a straight line lie on a plane, then the whole straight line lies on this plane.

* Axiom 2: There is one and only one plane passing through three points not lying on a straight line.

* Axiom 3: If there is one common point of two planes which do not coincide, then there is one and only one common straight line passing through this point.

* Axiom 4: Two lines parallel to the same straight line are parallel.

* Theorem: If the corresponding two sides of two angles in space are respectively parallel, then the two angles are either equal or complementary.

(ii) Through intuitive perception, confirmatory operation, reasoning and argumentation, and use the above-mentioned definitions, axioms and theorems in solid geometry as starting point, know and comprehend related properties and conditions for judging and determining parallel and perpendicular lines and planes in space. Through intuitive perception and confirmatory operation, induce the following theorems used for judgment and determination

* If one straight line outside is parallel to a straight line inside a plane, then this straight line is parallel to the plane.

* If two intersecting straight lines of one plane are parallel to another plane, then the two planes are parallel.

* If a straight line is perpendicular to two intersecting straight lines on a plane, then this straight line is perpendicular to the plane.

* If a plane passes through a perpendicular line of another plane, then the two planes are perpendicular.

Through intuitive perception and confirmatory operation, induce the following theorems used for judgment and determination of properties, and prove these theorems as well:

* If a straight line is parallel to a plane, then the line of intersection of any plane passing through this straight line and the plane are parallel to the straight line.

*If two planes are parallel, then the lines of intersection of any plane that intersects these two planes are mutually parallel.

* The two straight lines perpendicular to the same plane are parallel.

* If two planes are perpendicular, then a straight line of one plane perpendicular to the line of intersection of the two planes is perpendicular to another plane.

(iii) Able to deploy conclusions already acquired to prove some simple propositions of positional relationships in space.

2. Elementary Plane Analytical Geometry (about 18 class hours)

(1) Straight line and equation

(i) In a plane rectangular coordinates system, coupled with concrete figures, explore the geometric essentials ascertaining the position of straight lines.

(ii) Comprehend concept of inclination angle and slope of straight line; involve in the process of using algebraic method to depict the slope of a straight line; master the formula of calculating the slope of a straight line passing through two points.

(iii) Able to judge and determine that two straight lines are parallel or perpendicular in accordance with the slopes.

(iv) According to the geometric essentials ascertaining the position of straight line, explore and master the different forms of equations of straight line (point slope form, two point form, and general form); realize the relationship between slope intercept form and linear equation.

(v) Able to use method of solving system of equations to find the coordinates of the point of intersection of two straight lines.

(vi) Explore and master the formula of distance between two points, formula of distance of a point to a straight line; able to find the distance between two parallel straight lines.

(2) Circle and equation

(i) Recall the geometric essentials ascertaining circle; explore and master the standard equation and general equation of a circle in a plane rectangular coordinates system.

(ii) Able to determine the positional relationships between a straight line and a circle, as well as between two circles based on the given equations of straight line and circle.

(iii) Able to use equations of straight line and circle to solve some simple problems.

(3) During the initial process of learning plane analytical geometry, realize the idea of using algebraic method to handle geometric problems.

(4) Rectangular coordinates system in space

(i) Through concrete situations and contexts, feel the necessity of establishing rectangular coordinates system in space; familiarize with rectangular coordinates in space; able to use rectangular coordinates system in space to depict position of points.

(ii) Through representation of coordinates of vertex of special cuboids (all edges are parallel to the coordinate axes respectively), explore and find the distance formula between two points in space.

Mathematics 3: Preliminary algorithms, statistics, probability

1. Elementary Algorithm (about 12 class hours)

(1) Meanings of algorithm, procedural block diagram

(i) Through analyses of processes and steps of solving practical problems (e.g. solving of problems involving system of linear equations in two unknowns), realize the idea of algorithm; familiarize with the meanings of algorithm.

(ii) Through imitation, operation, and exploration, involve in expressing the processes of problem solving while designing block diagrams. During the processes of solving practical problems (e.g. solving of problems involving system of linear equations in three unknowns), comprehend the three basic logical structures of block diagrams: sequence, conditional branch, and loop.

(2) Basic algorithmic statements. Involve in the process of transforming procedural block diagrams of concrete problems into program statements; understand a few basic algorithmic statements: input statement, output statement, assignment statement, conditional statement, and loop statement; proceed to realize basic idea of algorithm.

(3) Through reading cases of algorithms in ancient Chinese mathematics, realize the contribution of ancient Chinese mathematics to mathematics development in the world.

2. Statistics (about 16 class hours)

(1) Random sampling

(i) Able to raise some valuable statistics problems in realistic everyday living and other subjects.

(ii) Combined with concrete practical problem contexts, comprehend the necessity and importance of random sampling.

(iii) During processes of participating in statistical problem solving, students are able to use simple random sampling method to draw samples from a population; through analyses of real cases, familiarize with methods of stratified sampling and systematic sampling.

(iv) Able to collect data through methods such as experimentation, information search, and design of questionnaire.

(2) Using sample to estimate population

(i) Realize through real examples the meanings and functions of distribution; during the processes of sample data representation, students learn how to tabulate frequency distribution table, draw frequency distribution histogram, frequency line graph, stem-and-leaf diagram, and realize their respective characteristics.

(ii) Through real examples comprehend the meanings and function of standard deviation of sample data; learn how to calculate the standard deviation of data.

(iii) Able to select appropriate sample in accordance with the requirements of practical problems; able to extract basic characteristics of numbers (e.g. mean, standard deviation) from sample data, and to put forward an appropriate explanation.

(iv) During the process of solving statistical problem, move a step further to realize the idea of using sample to estimate population; able to use sample frequency distribution to estimate population distribution; able to use basic sample characteristics of numbers to estimate basic population characteristics of numbers; begin to realize the randomness of sample frequency distribution and characteristics of numbers.

(v) Able to use basic method of random sampling and idea of using sample to estimate population and solve some simple practical problems; able to provide some evidences for informed decision by means of data analysis.

(vi) Form consciousness of preliminary evaluation of processes related to data processing.

(3) Correlation of variables

(i) Through data collection of two variables related to each other encountered in realistic problems, construct and use a scatter diagram to know intuitively the correlation relationship of the two variables.

(ii) Involve in the use of different estimation method to describe the process of describing the linear relationship of two variables; know the idea of least squares method; able to establish linear regression equation in accordance with given coefficient formula of linear regression equation (see Example 2).

3. Probability (about 8 class hours)

(1) In concrete situations and contexts, familiarize with the uncertainty of random events and stability of frequencies; proceed to familiarize with the meaning of probability, as well as the difference between frequency and probability.

(2) Through concrete examples, familiarize with the probability addition formula of two mutually exclusive events.

(3) Through concrete examples, comprehend classical probabilistic model and the associated probability computational formulae; able to use enumeration method to calculate the number of basic events in some random events, and the probability that these events happened.

(4) Familiarize with the meanings of random numbers; able to deploy modeling methods (including generation of random numbers to carry out modeling using calculators) to estimate probability; begin to realize the meanings of geometric probabilistic models (see Example 3).

(5) Through reading materials, familiarize with the processes of knowing random phenomena by human being.

Mathematics 4: Basic elementary function II (trigonometric function), vectors on a plane, trigonometric identity transformation

1. Trigonometric Functions (about 16 class hours)

(1) Arbitrary degree, radian measures. Familiarize with concepts of arbitrary angles and the radian measure. Able to convert from radian measures into degree measures, and vice versa.

(2) Trigonometric functions

- (i) Make use of the unit circle to understand definition of trigonometric functions (sine, cosine, tangent) of an arbitrary angle.
- (ii) Make use of the directed line segments of trigonometric functions in the unit circle to derive the induction formulae (sine, cosine, and tangent of $\pi/2 \pm\alpha$, $\pi\pm\alpha$), able to draw the graphs of $y = \sin x$, $y = \cos x$, $y = \tan x$, familiarize with the periodicity of trigonometric functions.
- (iii) Make use of graphs to understand the properties (such as monotonicity, maximum and minimum, points of intersection with the x-axis) of sine function, cosine function on $[0, 2\pi]$, and tangent function on $(-\pi/2, \pi/2)$.
- (iv) Understand basic formulae relating trigonometric functions of the same angle: $\sin^2 x + \cos^2 x = 1$, $\sin x/\cos x = \tan x$.
- (v) Using concrete real examples, familiarize with the practical meanings of $y = A\sin(\omega x +\varphi)$; able to make use of a calculator or computer to draw the graph of $y = A\sin(\omega x +\varphi)$, and observe the influence of parameters A, ω, and φ on changes of the graphs of functions.
- (vi) Able to use trigonometric functions to solve some simple practical problems; realize that trigonometric functions are important function models to describe phenomena of periodic changes.

2. Plane Vectors (about 12 class hours)

(1) Practical background of plane vectors and basic concepts through examples of force and its analyses, students are familiar with the practical background of vectors; understand plane vectors and the meanings of equality of two vectors, as well as understand geometric representation of vectors.

(2) Linear operation of vectors

- (i) Through real examples, master operations of addition and subtraction of vectors, and to understand their geometric meanings.
- (ii) Through real examples, master operation of scalar multiplication of vectors and understand their geometric meanings; understand meanings of collinearity of two vectors.
- (iii) Familiarize with properties of linear operation of vectors and their geometric meanings.

(3) Basic theorems of plane vectors and their coordinate representation.

- (i) Familiarize with basic theorems of plane vectors and their meanings.
- (ii) Master orthogonal decomposition of plane vectors and their coordinate representation.
- (iii) Able to use coordinates to represent operations of addition, subtraction and scalar multiplication of plane vectors.
- (iv) Understand the conditions under which two plane vectors, when represented using coordinates, are collinear

(4) Inner product of plane vectors

(i) Through real examples of "power" in physics, understand the meanings of inner product of plane vectors, as well as the associated physical meanings.

(ii) Realize relationships of inner product of plane vectors with the projection of vectors.

(iii) Master coordinates representation of inner product; able to carry out operations of inner product of plane vectors.

(iv) Able to use inner product to represent the included angle of two vectors; able to use inner product to determine the perpendicular relationship of two plane vectors.

(5) Application of vectors. Involve in using method of vectors to solve some simple plane geometric problems, as well as problems related to forces and processes pertaining to some practical problems. Students realize that vector is a tool that may be used to solve geometric problems, physics problems, etc. Students develop abilities of operations, as well as abilities of solving practical problems.

3. Trigonometric Identical Transformation (about 8 class hours)

(1) Involve in the process of deriving the cosine formula of difference of two angles using inner product of vectors, and proceed further to realize the function of vector method.

(2) Using the cosine formula of difference of two angles, able to derive the sine, cosine, and tangent formulae of sum and difference of two angles, as well as the sine, cosine, and tangent formulae of an angle that has been doubled; familiarize with the interrelationships amongst them.

(3) Able to apply the above-mentioned formulae to carry out identical transformation (including guiding students to derive transformation formulae involving product of trigonometric functions into sums and differences, sums and differences of trigonometric functions into products, and trigonometric functions of angle measures that have been halved. There is no need to memorize these formulae.)

Mathematics 5: Solution of a triangle, sequence, inequality

1. Solution of a Triangle (about 8 class hours)

(1) Through exploring the relationships of the length of the sides and the measure of the angles of any given triangle, students master theorem of sine's and theorem of cosine's theorem, cosine theorem, and are able to solve some simple metric problems for triangles.

2. Number Sequence (about 12 class hours)

(1) Concepts of number sequence and its simple method of representation through real examples in everyday living, familiarize with concepts of number sequence and several simple methods of representation (tabulation, graph, formula of general term); know that number sequence is a special kind of function.

(2) Arithmetic progression, geometric progression

(i) Through real examples, understand concepts of arithmetic progression and geometric progression.

(ii) Explore and master the formula of the general term of arithmetic progression and geometric progression, as well as the formula of the sum of the first n terms.

(iii) Able to discover common difference and common ratio relationships in number sequences within concrete problem contexts.

(iv) Realize the inter-relationships between arithmetic/geometric progressions with linear/exponential functions.

2. Inequalities (about 16 class hours)

(1) Unequal relationships through concrete situations and contexts, feel the existence of a large quantity of unequal relationships in the realistic world and everyday living.

(2) Quadratic inequalities in one unknown.

(i) Involve in the process of abstracting model of quadratic inequalities in one unknown from practical situations and contexts.

(ii) Through graphs of functions familiarize with the relationships of quadratic inequalities in one unknown with the corresponding functions and equations.

(iii) Able to solve quadratic inequalities in one unknown; able to design the procedural block diagram of the solution process given a quadratic inequality in one unknown.

(3) System of linear inequalities in two unknowns and simple linear programming problems.

(i) Abstract a system of linear inequalities in two unknowns from practical situations and contexts.

(ii) Familiarize with the geometrical meanings of linear inequality in two unknowns; able to use plane regions to represent system of linear inequalities in two unknowns (see example 2).

(iii) Able to abstract some simple linear programming problems in two unknowns, and solve them accordingly (see example 3).

(4) Basic Inequality: Square root of (ab) is less than or equal to a + b/2,~ (a, b both non-negative)

(i) Explore and familiarize with the proving process of the Basic Inequality.

(ii) Able to use Basic Inequality to solve simple maximum (or minimum) problems.

More advanced topics

* Series 1: Consists of 2 modules.

Optional Study 1-1: Common logic terminology, conic section and equation, derivative and its application.

Optional Study 1-2: Case studies of statistics, inference and proof, extension of number system and introduction of complex number, block diagram.

*Series 2: Consists of 3 modules

Optional Study 2-1: Common logic terminology, conic section and equation, vectors in space and solid geometry

Optional Study 2-2: Derivative and its application, inference and proof, extension of number system and introduction of complex number

Optional Study 2-3: Principle of enumeration, case studies of statistics, probability

*Series 3: Consists of 6 special topics

Optional Study 3-1: Selected topics of history of mathematics

Optional Study 3-2: Information security and cryptogram

Optional Study 3-3: The geometry of the sphere

Optional Study 3-4: Symmetry and group

Optional Study 3-5: Euler's formula and classification of closed surfaces

Optional Study 3-6: Trisection of an angle and extension of a number field

*Series 4: Consists of 10 special topics

Optional Study 4-1: Selected topics of geometrical proofs

Optional Study 4-2: Matrix and transformation

Optional Study 4-3: Sequence and difference

Optional Study 4-4: Coordinates system and parametric equations

Optional Study 4-5: Selected topics of inequalities

Optional Study 4-6: Elementary number theory

Optional Study 4-7: Optimum seeking method and preliminary experimental design

Optional Study 4-8: Overall planning (critical path method) and preliminary graph theory

Optional Study 4-9: Risk and decision making

Optional Study 4-10: Switching circuits and Boolean algebra

Series 1 is meant for those students who wish to further themselves in the humanities and social sciences.

Series 2 is set up for those who are interested in science and technology, and economics. Contents of series 1 and series 2 are fundamental contents of the optional curriculum.

Series 3 and series 4 are meant for students who are wish to elevate their level of mathematical literacy. Contents reflect important mathematical thinking that is helpful to build up foundational knowledge, increase application awareness, is beneficial to life-long development and extension of mathematical perspectives, as well as increase recognition of scientific, application, and cultural values of mathematics. Scope of the special topics will be broadened as the curriculum develops.

Endnotes

1. See http://www.washingtonpost.com/politics/how-bill-gates-pulled-off-the-swift-common-core-revolution/2014/06/07/a830e32e-ec34-11e3-9f5c-9075d5508f0a_story.html

2. See, for example, the response by Bill Honig, head of the California Department of Education in the late 1980s and early 1990s, to Peter Wood's article on the CCS at: http://www.nas.org/articles/common_complaints

3. See, for example, Tamar Lewin. (2014, March 5). A new SAT aims to realign with schoolwork. *New York Times*. http://www.nytimes.com/2014/03/06/education/major-changes-in-sat/

4. See, for example, at the CCS official website— http://www.corestandards.org/about-the-standards/development-process —"During the development process, the standards were divided into two categories:
   • First, the college- and career-readiness standards, which address what students are expected to know and understand by the time they graduate from high school
   • Second, the K-12 standards, which address expectations for elementary school through high school
   The college- and career-readiness standards were developed first and then incorporated into the K-12 standards in the final version of the Common Core we have today."

5. William Schmidt, Richard Houang, & Leland Cogan. (2002, Summer). A Coherent Curriculum: The Case of Mathematics, *American Educator*, 26(2), 1–18. The paper compares the curricula of A+ countries with ours in grades 1–8.

6. See Barry Garelick. (2014). *Letters from John Dewey/Huck Finn: A look at math education from the inside*. San Bernardino, CA: William R. Parks Publishing, Part II.

7. See http://www.achieve.org/adp-benchmarks

8. See http://www.fayar.net/east/teacher.web/math/Standards/Previous/CurrEvStds/currstand5-8.htm

9. See, for example, Diane Ravitch. (2000). *Left Back*, New York: Simon and Schuster; and Susanne M. Wilson. (2002). *California dreaming: Reforming mathematics education*, New Haven, CT: Yale University Press. See also Klein, David. (2003). A Brief History Of American K-12 Mathematics Education In the 20th Century, In James M. Royer, (Ed.), *Mathematical Cognition*, (pp. 175–226). Charlotte, NC: Information Age Publishing.

10. See Barry Garelick (2014). *Conversations on the Rifle Range, I: Not Your Mother's Algebra 1 and the Guy Who Really Knows*. *Out in Left Field*. http://oilf.blogspot.com/2014/06/conversations-on-rifle-range-i-not-your.html

11. See Barry Garelick, (2014, April 22). Standards for Mathematical Practice: The Cheshire Cat's Grin, *Education News*. http://www.educationnews.org/k-12-schools/standards-for-mathematical-practice-the-cheshire-cats-grin/

12. For an overview of these issues, see "Math Education Reform: Does It Add Up?" (2011, April). *EdCast*, with Elizabeth Carson, Fred Greenleaf, and Sylvain Cappell, Courant Institute of Mathematical Sciences, New York University. [video] http://nychold.org/ See also Klein, David. (2003). A Brief History Of American K-12 Mathematics Education In the 20th Century, In James M. Royer, (Ed.), *Mathematical Cognition*, (pp. 175–226). Charlotte, NC: Information Age Publishing.

13. Brookings Institution. (2012, November 29). "Standardized Testing and the Common Core," Washington, DC: Author, p. 22 http://www.brookings.edu/~/media/events/2012/11/29%20standardized%20testing/20121129_standardized_testing.pdf

14. The example comes from a worksheet used in a Connecticut public school. The provider chooses to remain anonymous.

15. In this approach, it is not appropriate to give actual proofs of the triangle congruence conditions SSS, SAS, and ASA at the K–12 level, and Common Core is forced to recommend hand-waving—just using the teacher's authority to claim the truth of the statements, but not justifying them in any other way—in spite of the fact that congruence can be easily demonstrated using traditional approaches.

16. See "The Common Core Dissenters" at http://nonpartisaneducation.org/

17. David Coleman. (2011, December 8–9). Senior Leadership Meeting Keynote Address: "What must be done in the next two years." University of Pittsburgh, Institute for Learning. http://ifl.lrdc.pitt.edu/index.php/download/index/transcript_david_coleman

18. National Center on Education and the Economy, *What does it really mean to be college and work ready? The mathematics and English literacy required of the first year community college student*. Washington, D.C.: Author. http://www.ncee.org/what-does-it-really-mean-to-be-college-and-work-ready/

19. William McCallum. (2010, January). National Meeting of the American Mathematics Society; John Fensterwald. (2010, January 17). "Common Core Standards under fire." *Thoughts on Public Education*, Silicon Valley Education Foundation. http://pioneerinstitute.org/video/audio-lead-mathematics-standards-writer-william-mccallum/
Jason Zimba. (2010, March 23). Public testimony, Massachusetts Board of Elementary and Secondary Education. http://pioneerinstitute.org/news/video-common-core-lead-writer-jason-zimba/;
James Milgram and Sandra Stotsky. (2013). *Lowering the bar.* Boston, MA: Pioneer Institute. http://pioneerinstitute.org/news/lowering-the-bar-how-common-core-math-fails-to-prepare-students-for-stem/

20. The dictionary meaning of "rigorous" in normal usage in mathematics is "the quality or state of being very exact, careful, or strict" but in educationese it is "assignments that encourage students to think critically, creatively, and more flexibly." Likewise, educationists may use the term *rigorous* to describe "learning environments that are not intended to be harsh, rigid, or overly prescriptive, but that are stimulating, engaging, and supportive." In short the two usages are almost diametrically opposite. See http://edglossary.org/rigor/.

21. In the *Pirates of the Caribbean* films, Hector Barbossa was played by Geoffrey Rush.

22. PARCC received $185,862,832 on August 13, 2013. https://www2.ed.gov/programs/racetothetop-assessment/parcc-budget-summary-tables.pdf; SBAC received $175,849,539 to cover expenses to September 30, 2014. https://www2.ed.gov/programs/racetothetop-assessment/sbac-budget-summary-tables.pdf. There are other sources of funds, but any one of them is small in comparison with these two disbursements.

23. See, for example, **For California:** Michael W. Kirst & Christopher Mazzeo, (1997, December). The Rise, Fall, and Rise of State Assessment in California: 1993-96, *Phi Delta Kappan*, 78(4)
Committee on Education and the Workforce, U.S. House of Representatives, One Hundred Fifth Congress, Second Session, (1998, January 21). National Testing: Hearing, Granada Hills, CA. Serial No. 105-74;
Representative Steven Baldwin, (1997, October). Comparing assessments and tests. *Education Reporter, 141.* See also Klein, David. (2003). A Brief History Of American K-12 Mathematics Education In the 20th Century, In James M. Royer, (Ed.), *Mathematical Cognition*, (pp. 175–226). Charlotte, NC: Information Age Publishing.
For Kentucky: ACT. (1993). A study of core course-taking patterns. ACT-tested graduates of 1991-1993 and an investigation of the relationship between Kentucky's performance-based assessment results and ACT-tested Kentucky graduates of 1992. Iowa City, IA: Author; Richard Innes. (2003). Education research from a parent's point of view. Louisville, KY: Author. http://www.eddatafrominnes.com/index.html; KERA Update. (1999, January). Misinformed, misled, flawed: The legacy of KIRIS, Kentucky's first experiment.
For Maryland: P. H. Hamp, & C. B. Summers. (2002, Fall). "Education." In P. H. Hamp & C. B. Summers (Eds.), A guide to the issues 2002–2003. Maryland Public Policy Institute, Rockville, MD. http://www.mdpolicy.org/

docLib/20051030Education.pdf; Montgomery County Public Schools. (2002, Feb. 11). "Joint Teachers/Principals Letter Questions MSPAP", Public Announcement, Rockville, MD. http://www.montgomeryschoolsmd.org/press/index.aspx?pagetype=showrelease&id=644; HumRRO. (1998). Linking teacher practice with statewide assessment of education. Alexandria, VA: Author. http://www.humrro.org/corpsite/page/linking-teacher-practice-statewide-assessment-education;

24. http://www.nashuatelegraph.com/news/1027308-469/nashua-middle-school-principal-outlines-serious-concerns.html

25. Assumption in parentheses added by authors. It was assumed but not explicitly stated in the original.

26. See the Race to the Top regulations (U.S. Education Department, p. 18172):
"Assessment systems developed with Comprehensive Assessment Systems grants must include one or more summative assessment components in mathematics and in English language arts that are administered at least once during the academic year in grades 3 through 8 and at least once in high school and that produce student achievement data and student growth data (both as defined in this notice) that can be used to determine whether individual students are college- and career-ready (as defined in this notice) or on track to being college- and career ready (as defined in this notice).
"Finally, assessment systems developed with Comprehensive Assessment Systems grants must produce data (including student achievement data and student growth data) that can be used to inform (a) determinations of school effectiveness; (b) determinations of individual principal and teacher effectiveness for purposes of evaluation;…"

27. According to the Chronicle of Higher Education (May 16, 2012) <http://chronicle.com/article/With-Choice-of-New-Leader/131901/>,Coleman was chosen because: "We saw new synergy," Lester P. Monts, a former College Board trustee who led the search committee, said of Mr. Coleman. "We need linkages. The College Board's programs and services, the AP and the SAT, these only reach down so far. When you consider that the Common Core reaches all the way down to pre-kindergarten, it just seems to be a linkage that will benefit both K-12 and higher education."
"Mr. Monts, who is senior vice provost for academic affairs at the University of Michigan at Ann Arbor, said members of the committee wanted someone with an entrepreneurial spirit like Mr. Caperton. "The ability to take risks," he said, "that is sort of David Coleman's profile."
"Mr. Coleman has already said that he hopes to align the SAT with the Common Core standards."

28. As if to highlight his poor understanding of assessment, Coleman asserted at a Brookings Institution conference (p. 24 of transcript), "It does help the reliability of assessment to put shitty passages on tests." Foul mouth aside, he is exactly wrong: the more unclear and ambiguous a test item is, the less reliable it is. http://www.brookings.edu/~/media/events/2012/11/29%20standardized%20testing/20121129_standardized_testing.pdf

29. For details see the press release, College Board. (2014, March 5). "The College Board Announces Bold Plans to Expand Access to Opportunity; Redesign of the SAT." Author. https://www.collegeboard.org/releases/2014/expand-opportunity-redesign-sat

30. See http://www.fayar.net/east/teacher.web/math/Standards/Previous/CurrEvStds/currstand5-8.htm

31. The longtime director of research at the College Board, Wayne Camara, left shortly thereafter and now works at ACT.

32. For example, check out the testing and measurement expertise of Schmeiser confidants Ranjit Sidhu and Craig Jerald, now senior executives at College Board.

33. It is a sad fact that test developers can increase their profit margins through innovations that may, directly or indirectly, lower academic or test security standards.

34. Rebecca Zwick. (2007). *College admission testing*. Washington, D.C.: National Association of College Admission Counselors. For an extended discussion of the different histories and character of achievement and aptitude tests, see Richard P. Phelps, (2007). Aptitude or achievement: Two separate historical paths, chapter 2 in *Standardized Testing Primer*, New York: Peter Lang; Pinker, Steven. (2014). The Trouble with Harvard: The Ivy League is broken and only standardized tests can fix it. *The New Republic.* Retrieved September 5, 2014 from http://www.newrepublic.com/article/119321/harvard-ivy-league-should-judge-students-standardized-tests

35. David Lohman. (2005, Summer). Is ability separate from achievement? *Cognitively Speaking*, 4, University of Iowa, Belin-Blank Center; David Lohman. (2006). "Beliefs about differences between ability and accomplishment: From folk theories to cognitive science" *Roeper Review*, 29, 32–40; David Lohman. (2009). Identifying academically talented students: Some general principles, two specific procedures. In Larisa Shavinina (Ed.) *International Handbook on Giftedness*. (pp. 971–998). Dordrecht, Netherlands: Springer.

36. See G. M. Lavergne. (2007, November 9). College admissions as conspiracy theory. *The Chronicle of Higher Education*, B9–B13; Wayne Camara. (2008). College admission testing: Myths and realities in an age of admissions hype. In R. P. Phelps, (Ed.), *Correcting fallacies about educational and psychological testing* (pp. 147–180), Washington, DC: American Psychological Association.

37. David Lohman. (2004). Aptitude for college: The importance of reasoning tests for minority admissions. In R. Zwick (Ed.), Rethinking the SAT: The future of standardized testing in university admissions, (pp. 41–56). New York: Routledge; J. S. Wyner, J. M. Bridgeland, & J. J. DiIulio, Jr. (n. d.) Achievement trap: *How America is failing millions of high-achieving students from lower-income families*. Lansdowne, VA & Washington, DC: Jack Kent Cooke Foundation & Civic Enterprises. See also Rebecca Zwick. (2004). Is the SAT a "wealth test"? The link between educational achievement and socioeconomic status. In R. Zwick (Ed.) *Rethinking the SAT*, pp. 203–216. Mahwah, NJ: Psychology Press.

38. College Board. (2014, March 5). "The College Board Announces Bold Plans to Expand Access to Opportunity; Redesign of the SAT." Author. https://www.collegeboard.org/releases/2014/expand-opportunity-redesign-sat

39. For another example, see Iasonas Lamprianou (2012) Unintended consequences of forced policymaking in high stakes examinations: the case of the Republic of Cyprus, *Assessment in Education: Principles, Policy & Practice*, 19:1, 27-44, DOI: 10.1080/0969594X.2011.608348. Cyprus, too, replaced separate secondary exit and postsecondary entrance exams with a single test, with unfortunate results.

40. In addition, some US-based critics of high school exit exams provide abundant evidence that they are not predictive of college work and argue for their elimination on that basis. (Not being psychometricians, they do not seem to realize that they are not designed to be predictive; they are designed to summarize mastery of the high school curriculum, something society considers important.) See, for example, Sean F. Reardon, Nicole Arshan, Allison Atteberry, & Michal Kurlaender. (2008, September). High stakes, no effects: Effects of failing the California High School Exit Exam, Paper prepared for the International Sociological Association Forum of Sociology, Barcelona, Spain, September 5–8; and John Robert Warren and Eric Grodsky, Exit Exams Harm Students Who Fail Them - and Don't Benefit Students Who Pass Them, *Phi Delta Kappan*, Vol. 90, No. 09, May 2009, p.p. 645-649.

41. For an overview of this issue, see Stephan Heyneman. (1987). *Uses of examinations in developing countries: Selection, research, and education sector management*. Seminar paper No. 36, Economic Development Institute, The World Bank, Washington, DC. "Where school inputs vary widely…academic achievement tests are likely to measure the opportunity to learn more than the ability to learn. [Developing] nations concerned about picking their future talent must consider the possibility that an aptitude test…may be more able to overcome the local differences in school quality" (p. 253)

42. They cited the change of affairs in California when Richard Atkinson was president of the university system as justifying precedent. Atkinson changed the admission requirements to deemphasize the SAT I (the standard SAT with Critical Reading and Mathematics) and emphasize SAT II subject tests. In other words, Atkinson replaced aptitude testing with achievement testing. The result: to reach the same levels of predictive validity required more than an hour's worth of additional testing. Shortly after Richard Atkinson retired, the University of California system resumed the previous admission regime.

43. N. Brandt. (2010) *Chile: Climbing on giants' shoulders: Better schools for all Chilean children*, Economics Department Working Papers No. 784, Washington, DC: World Bank; MIDE-UC. (2000). *Reformulacion de las Pruebas de Selección a la Educación Superior*, Proyecto FONDEF; Ministerio de Educación. (2000, Nov. 22). Comisión Nuevo Currículum de la Enseñanza Media y Pruebas del Sistema de Admisión a la Educación Superior, Santiago, Chile: Author; Organisation for Economic Co-operation and Development, and World Bank. (2009). *Tertiary Education in Chile*, Paris: OECD; World Bank. (2001, October 19). Implementation Completion Report (CPL-38830; SCL 38836); World Bank. (2005, December). *Implementation Completion Report* (TF-25378 SCL-44040 PPFB-P3360).

44. J. L. Kobrin, B. F. Patterson, E. J. Shaw, K. D. Mattern, & S. M. Barbuti. (2008). *Validity of the SAT for predicting first-year college grade point average*. (College Board Research Report No. 2008-5). New York: College Board; Richard P Phelps. (2014, Jan. 7). "Large-scale testing: Uses and abuses", Presentation at Universidad Finis Terrae, Santiago, Chile. http://www.finisterrae.cl/portada/item/richard-phelps-dictara-charla-sobre-pruebas-estandarizadas; Willingham, W. W., Lewis, C., Morgan, R., & Ramist, L. (1990). Implications of using freshman GPA as the criterion for the predictive validity of the SAT. *Predicting college grades: An analysis of institutional trends over two decades*. Princeton, NJ: Educational Testing Service; ACT Research Services. (n.d.). Research Services summary tables: Based on institutions in the 1997–98 prediction. Iowa City, IA: ACT.

45. A. M. Prado Salces. (2008). *Estudio de validez predictive de la PSU y comparacion con el sistema PAA*, Tesis para optar al grado de magister en economia aplicada, Memoria para optar al titulo de ingeniero civil industrial. Santiago, Chile: Universidad de Chile.

46. S. Prado. (2008, August 19). "Predicción y PSU". Carta al Editor. *El Mercurio*.

47. For a general overview of this issue, see Stephan Heyneman. (2004). Education and Corruption. *International Journal of Educational Development*, 24(6), pp. 637–648.

48. See, for example, Mladen Koljatic, & Mónica Silva. (2011, October). Acceso y Equidad en las Demandas Estudiantiles. *Revista de Administración y Economía*. Número Especial de Educación, pp. 24-29; Mladen Koljatic, & Mónica Silva. (2011, December 5). Acceso a la información y sistemas de medición en educación en Chile: El caso de las pruebas de admission. Seminario Educación y Transparencia organizado por Fundación ProAcceso; Mónica Silva. (2013, May 16). La pertinencia de la PSU y las necesidades de cambio en el sistema de selección universitaria. Paper presented at INACAP; Mónica Silva. (2013, August 23). Sistemas y Procesos de Selección y Admisión Universitaria. Paper presented for class in higher education administration, Pontificia Universidad Católica de Chile.

49. Educational Testing Service. (2004, December). *Suggestions for improving the comparability of scores on the PSU Prueba de Ciencias* (draft), Princeton: Author; Educational Testing Service. (2005, January). Evaluación Externa de las Pruebas de Selección Universitaria (PSU). Princeton: Author; Harald Beyer. (2007, January 17). "Equidad en PSU". Carta al Editor. *El Mercurio*; Pearson Measurement. (2013, January), Final Report: Evaluation of the Chile PSU.

50. Richard P. Phelps. (2014, Feb. 2). Evaluaciones educacionales de gran escala en Chile: Son necesarias? *CIPER*. http://ciperchile.cl/2014/02/06/evaluaciones-educacionales-de-gran-escala-en-chile-%C2%BFson-necesarias/

51. See chapters 1 & 7, Richard P Phelps (2005). *Kill the messenger: The war on standardized testing*. New Brunswick, NJ:

Transaction; and Richard P. Phelps. (2001, August). Benchmarking to the world's best in Mathematics: Quality control in curriculum and instruction among the top performers in the TIMSS. *Evaluation Review. 25*(4), 391–439.

52. See for example this figure from the Trends in Mathematics and Science Study (TIMSS); the key indicator is the spread of the squares in each country's bar: http://nces.ed.gov/timss/figure11_4.asp

53. I.e., all children, but for some with certain disabilities.

54. Clifford Adelman. (1999). *Answers in the Toolbox*. Washington, DC.: U.S. Department of Education; *http://www2.ed.gov/pubs/Toolbox/toolbox.html*; Clifford Adelman. (2006). *The Toolbox Revisited: Paths to Degree Completion from High School Through College*. Washington, DC: U.S. Department of Education. http://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf

55. A minimum competency test is a high-stakes test that requires performance at or above a single threshold test score before a certain attainment (e.g. high school diploma) will be recognized.

56. Economist John Bishop found that New York State high school graduates achieved superior academic and labor market outcomes than graduates from other states, other factors held equal. See Bishop, J.H. (2000, Summer). Diplomas for learning: Not for seat time. *Economics of Education Review*, 19, 333–349.

57. For example, Germany offers the *abendgymnasium* and France the *DAEU*. See DAEU: le diplôme de la seconde chance. (1996, Octobre). *Le Monde de l'Education*, 241, 81–84.

58. U.S. Department of Education. (2010, April 9). Overview Information: Race to the Top Fund Assessment Program; Notice Inviting Applications for New Awards for Fiscal Year (FY) 2010, *Federal Register Notices*, 75(68), 18172. "To help improve outcomes in career and technical education, we are also establishing a second competitive preference priority for applications that include a high-quality plan to develop, within the grant period and with relevant business community participation and support, assessments for high school courses that comprise a rigorous course of study in career and technical education that is designed to prepare high school students for success on technical certification examinations or for postsecondary education or employment." (Note the ambiguity of the term "rigorous" here. Is it being used in the usual sense or in educationese?)

59. Richard P. Phelps & Mónica Silva. (2014). The effect of testing on student achievement, 1910–2010: Meta-regression analysis. Paper presented at the 9th Conference of the International Test Commission, San Sebastian, Spain, July 5, 2014.

60. See, for example, Eleanor Chelimsky, *Student Achievement Standards and Testing*, T-PEMD-93-1. Washington, DC: US GAO.

61. Harold W. Stevenson, Shin-ying Lee, and James W. Stigler (1986). "Mathematics Achievement of Chinese, Japanese, and American Children." Science 231 (4739): 693–699; Harold W. Stevenson and James W. Stigler (1992). *The Learning Gap: Why Our Schools are Failing and What We Can Learn From Japanese and Chinese Education*. New York: Summit Books, pp. 13–27 in particular.

62. William Sanders pioneered the use of "value-added" measures in Tennessee and highlighted the importance of teacher quality in no-stakes (for anyone) tests. Thomas Kane (See http://www.brookings.edu/blogs/brown-center-chalkboard/posts/2014/05/29-incremental-education-reform-kane) and Erik Hanushek (http://dcps.dc.gov/DCPS/In+the+Classroom/Ensuring+Teacher+Success/IMPACT+%28Performance+Assessment%29/Value-Added) are among those who have promoted stakes-for-teachers/none-for-students policies.

63. Bishop, J. (1994). *The impact of curriculum-based examinations on learning in Canadian secondary schools* (CAHRS

Working Paper #94-30). Ithaca, NY: Cornell University, School of Industrial and Labor Relations, Center for Advanced Human Resource Studies. http://digitalcommons.ilr.cornell.edu/cahrswp/255; and Bishop, J.H., Moriarty, J.Y. & Mane, F. (1997). *Diplomas for learning, not seat time: The impacts of New York Regents Examinations* (CAHRS Working Paper #97-31). Ithaca, NY: Cornell University, School of Industrial and Labor Relations, Center for Advanced Human Resource Studies. http://digitalcommons.ilr.cornell.edu/cgi/viewcontent.cgi?article=1170&context=cahrswp

64. See “The secondary school examination systems in countries in the SEAMEO Region.” http://www.seameo.org/vl/library/dlwelcome/publications/ebook/exam/2ndintro.htm

65. See, for example, Linda Darling-Hammond and Laura McCloskey, “Assessment for Learning around the World: What Would it Mean to Be ‘Internationally Competitive?’” Unpublished manuscript, Stanford University.

66. *The Economist*. (2013, December 7). “School league tables: Finn-ished” Author. See also: Astela, et al. (2006, December). “The PISA survey tells only a partial truth of Finnish children’s mathematical skills.” *Matilde*, 29, 9; Kivelä. (2006, December). “Severe shortcomings in Finnish mathematics skills.” *Matilde*, 29, 10; and G. Malaty. (2006, December). “What are the reasons behind the success of Finland in PISA?” *Matilde*, 29, 4–8.

67. In fact, Finland only de-emphasizes external testing, not accountability. A grade 9 test is high stakes and determines a student’s fate—vocational or academic track in grade 10. Then there is a matriculation examination in grade 12 for the academic track, and only a small fraction—less than 50%—of those who pass the matriculation exam continue to state universities. In other words, it is not even sufficient to pass; one needs to pass it “well” to continue to university. Further, slightly over 40% of Finnish students end up in the vocational track in grade 10, and about half in the academic one. About 9% drop out between grades 9 and 10.
Finally, there is a rigorous internal testing done by teachers every few weeks in Finland, with grades ending up in each student’s file and counting towards the later high-stakes decisions.

68. Richard P. Phelps. (2005, February). Educational testing policy: Stuck between two political parties, *Yale Politic*. http://www.nonpartisaneducation.org/Foundation/YalePoliticArticle.htm;
Richard P. Phelps. (2007, Summer). The dissolution of education knowledge. *Educational Horizons. 85*(4), 232–247. http://www.nonpartisaneducation.org/Foundation/DissolutionOfKnowledge.pdf;
Richard P. Phelps. (2012, Summer). Dismissive reviews: Academe’s Memory Hole. *Academic Questions*. http://www.nas.org/articles/dismissivereviewsacademesmemoryhole;
Richard P. Phelps. (2012). The rot festers: Another National Research Council report on testing. *New Educational Foundations, 1*. http://www.newfoundations.com/NEFpubs/NEFv1n1.pdf

69. Clifford Adelman. (1999). *Answers in the Toolbox.* Washington, D.C.: U.S. Department of Education. http://www2.ed.gov/pubs/Toolbox/toolbox.html; Clifford Adelman. (2006). *The Toolbox Revisited: Paths to degree completion from high school through college*. Washington, D.C.: U.S. Department of Education. http://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf

70. Other scholars have corroborated Adelman’s findings many times since. Perhaps most publicly, the testing company ACT published a series of research reports based on analyses of their own massive databases of the factors contributing to college success, under titles such as: *Crisis at the Core* (2004; http://www.act.org/research/policymakers/reports/crisis.html) (e.g., "Our research also confirms that taking and doing well in specific courses—such as Biology, Chemistry, Physics, and upper-level mathematics (beyond Algebra II)—has a startling effect on student performance and college readiness." (p. i); "Seventy-four percent of students who took Trigonometry and Calculus in addition to the three-course sequence Algebra I, Algebra II, and Geometry met the benchmark for college Algebra, as did 55 percent of students who took these three courses plus Trigonometry and one other upper-

level mathematics course, and 37 percent of students who took the three courses plus Trigonometry (Figure 21). At 13 percent, students who took only Algebra I, Algebra II, and Geometry were no more successful at meeting the benchmark than were students who took less than these three years." (p.12)); *On Course for Success* (2005; http://www.act.org/research/policymakers/reports/success.html) (e.g., Figure 1.3 (p. 4)); *Courses Count* (2005; http://www.act.org/research/policymakers/pdf/CoursesCount.pdf) (e.g., Figure 2 (p. 5)), and *Rigor at Risk* (2007; http://www.act.org/research/policymakers/reports/rigor.html).

71. Hobel contributed these comments to a listserv. The data on which her comments are based are on her website: http://www.hobel.org/mva/id67.htm

72. U.S. Department of Education, National Center for Education Statistics. (2013). *STEM in postsecondary education: Entrance, attrition, and course-taking among 2003¬–2004 beginning postsecondary students*, Report 2013-152, Washington, DC: Author, Table 7, p. 23.

73. PARCC. (2011, July 29). Higher education to help develop assessments. http://parcconline.org/print/higher-education-help-develop-and-implement-new-assessments

74. It is highly unclear what this actually means since, previous to Common Core, “beginning college algebra” was generally regarded as remedial, and we have no indications that “introductory statistics” is intended to be more than mathematics-free high school discussions. In today's better universities, a serious course in statistics commonly requires a solid knowledge of first year college calculus, with strong recommendations that the student have had a course in linear algebra as well. But this level of background will take years to achieve for the vast majority of students entering universities under Common Core.

75. US Department of Education. (2010, April 9). Overview Information: Race to the Top Fund Assessment Program; Notice Inviting Applications for New Awards for Fiscal Year (FY) 2010, *Federal Register Notices*, 75(68), p. 18172.

76. See, for example, PARCC’s “Frequently Asked Questions” (FAQforCCRDandPLD_Updated11-1-12.pdf), pp. 1-3.

77. See, for example, PARCC’s “Frequently Asked Questions” (FAQforCCRDandPLD_Updated11-1-12.pdf), p. 4.

78. Many of the aptitude characteristics of the SAT have already disappeared (e.g., analogies). The complete transformation of the Mathematics SAT into a curriculum-aligned achievement test may have been inevitable (which does not make it any less regrettable). Indeed, some SAT critics deride aptitude testing in college admissions on the grounds that it failed to incentivize students to work harder in their high school courses. See, for example, Christopher Jencks, & J. Crouse. (1982, Spring). Aptitude vs. Achievement: Should we replace the SAT? *National Affairs, 67*. But, those particular incentives are not all that matter and, we believe, are easily outweighed by other incentives, a substantial lowering of standards in both high school and college, and a degradation of the quality of information provided to college admission counselors.

79. As might have been expected, new College Board PR staff is now busy responding to the concern of a decline in predictive validity due to the CCS alignment by assuring us all that there is nothing to worry about. See, for example, Emmeline Zhao. (2014, March 7). New SAT revision: 5 questions with Kathleen Porter-Magee. *Real Clear Education*.

80. Arthur G. Powell. (1997, Fall). “Student incentives and the College Board system.” *American Educator*. Washington, D.C.: American Federation of Teachers.

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