The state math proficiency and math proficiency growth rate data excerpts for THE U.S. STATE and City GOVERNMENTS relevant for the USL 0.25, 0.5 and 1.0 (version 1)

By Dongchan Lee

Date: February 18, 2015

ABSTRACT

USL 0.5 is designed to boost the city or state average school math levels to advance about 1 year although it normally takes 8-25 years for the U.S. states and the average will take about 16 years (according to NAEP).

USL 1.0 is designed to boost the national average school math levels to advance about 2 years although it normally takes minimum 15-50 years for the U.S. states and the average will take at least 30 years even if they are very lucky; chances are about 40 years as the progress normally slows down significantly even for the fastest growing states or countries for boosting the school math average.

This short paper is designed to provide some of the key information as to why the various states and major cities should consider the USL 0.25 or 0.5 pilot studies in 2015 as early as possible as the costs will be minimal compared to the colossal gains that the city or the state governments will gain over the rest of this century. As the USL reforms for the states will last 1-3 years or so, our projections will be 1.3-1.7x larger than Hanushek-Woessmann projections.

1) USL 0.25 will boost the state school math averages by half a year and its Real GDP contribution for the states are expected to be 4x-5x than now by USL 0.5
2) USL 0.5 will boost the Real GDP contribution for the states at least 10x larger than now (most likely about 13-16x larger).
3) USL 1.0 will boost the Real GDP contribution for the states at least 20-25x larger than now (most likely about 25-30x larger).

We included the key data on the U.S. state math proficiency charts, statewide school math annual growth rates.


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INTRODUCTION
The USL series will rely on the following 3 major aspects: the results from Eric Hanushek and Ludger Woessmann (which we call HW rule) that says

1) that advancing about 0.5 standard deviation of cross-country school math assessment scores such as PISA or TIMSS corresponds to 1% of the surplus Real (not nominal) GDP per capita growths for the rest of the century;
2) that 0.5 Standard deviation is roughly equal to 1 year school math level differences nationwide or statewide;
3) that normally speaking, at the national levels, to advance the national school math by 1 year takes a few or several decades in average or to advance by 2 years takes half a century or more in the past history since 1960s at least, but the USL series will achieve these over the next 2-5 years and inviting your state to start the first revolution.

The massive economic implications of USL 0.5 and 1 within short years

In this section, we reanalyze the charts from the World Bank paper by Hanushek and Woessmann to present the tight correlation between the international cognitive skill test results for math or others vs. the Real GDP per capita growth rate. Throughout the over 1.5 decade’s papers by Hanushek and Woessmann, they have been consistently demonstrating that the national average math scores particularly - more than any other cognitive skills – have the driving force for the Real GDP growth rates.

For our purpose, if we use their results, in general, roughly 1 standard deviation of national math scores from PISA (or TIMSS, which corresponds roughly to 2 years of math level difference corresponds to about 1.8-2% of the Real GDP per capita difference, which is exactly what USL1 is trying to push.

In the following charts of Figure 4 and 5 from the World Bank Policy Research Working Paper, the vertical axis show the Real GDP per capita annual growth rates and the horizontal axis is for the international test scores (particularly math scores). They are designed in such a way that roughly about 2.25 standard deviations roughly correspond to the 5.5 Real GDP per capita growth rate differences. For the PISA tests, for instance, 0.5 standard deviation roughly corresponds to about 1 year of school math level difference. So this means that about 4.5 Real GDP growth rate difference as the results were taken during 1960-2000 (about 4 decades’ results).
You may wonder if the average math test scores drive the Real GDP growth rates or the other way around. If the economic power drives the national average math scores or other cognitive skill results from PISA or TIMSS, etc., then we expect more schoolings or expenditures per student will drive the higher international test scores like PISA or TIMSS, but that kinds of correlations are rather very weak if you look at the charts below.

The research reported here suggests that each year of schooling boosts long-run growth by 0.58 percentage points (figure 2).

So about 7 years of schooling driving about 4% difference of Real GDP per capita difference valid for over 40 plus years?

Not quite.
When Hanushek and Woessmann ran the regressions with the cognitive skills (such as math) out, it turns out the years of schoolings make no big difference. 6-7 of schooling years make less than a quarter of 1% of Real GDP per capita growth rate difference.

How about the national expenditures of schools?

In the chart given here, 4x more cumulative education expenditure per student barely make 50 point difference in PISA which is like advancing 1% surplus Real GDP per capita (USD in PPP).
(OECD-PISA, 2014)

If you look at the PISA 2012 data on the left side chart above here, the PISA score difference of about 1 year (between the score of 450 and 500) roughly corresponds to the GDP per capita difference (NOT their growth rate) between 10 USD and 47 USD (in PPP), but the correlation is first of rather weak (R squared is 0.21) and the view for the GDP per capita to drive the test scores of math or other cognitive skills is quite weak.

If you look at the PISA 2012 data on the right side chart above here, cumulative spending on education (USD in PPP), the PISA score difference between 450 and 500 (about 1 year difference), which will roughly corresponding to the 1% of Real GDP per capita, corresponds roughly to the difference between 100 USD and 20 USD, which is about 4x difference. Quite similar to the result above from 2004.

Now, if you put the Figure 2 and Figure 4 of this section together, roughly 4% Real GDP per capita difference on the vertical axes correspond simultaneously to about 2 standard deviation of the national test scores (in this case, PISA math) and also to about 7 years of schoolings. Other studies seem to correspond to 6-12 years of schoolings, etc. If we use this correspondence here, we can estimate roughly that advancing the 2 year school math levels (corresponding to roughly about 2% of Real GDP per capita growth boost) will correspond roughly to add 3.5 years of more schoolings nationally.

(Hanushek & WoBmann, 2007)
The intimate connections: 1 year of average school math level difference vs. the surplus 1% of Real GDP per capita growth rate

50 point of math difference on PISA is roughly equivalent to the 1-1.1 school math schooling difference. On the far right column it indicates that this difference will impact the extra 1% of Real GDP growth rate. The second columns indicate how much will the U.S.A. Real GDP will be in 80 years. As the USL 0.5 roughly corresponds except that their reform time projections are 20 or 10 years while the USL series reform times in the U.S.A. states will be 2-4 years, USL 0.5-induced Real GDP growth to the states that embrace will be not 8x larger than now (if the reforms take 10 years), but over 10x larger than now. This is Real GDP, NOT nominal GDP growths. Furthermore, Hanushek-Woessmann projections are rather conservative. In contrast, if there is no school math reforms nationwide, the expected Real GDP of the U.S.A. in 80 years will be roughly 2.5x-3x larger than now. In other words, the USL 0.5-induced Real GDP growths of your states will be roughly or at least 2x larger than without USL 0.5 reforms. On the other hand, if USL 1.0 is embraced by the U.S. states, then the surplus Real GDP will be 20x-30x larger, averaging about 25x larger than without.

(Hanushek & Woessmann, 2011)

The following is a direct quote from their UNESCO paper.

Results of Projections

The results are displayed in Table 2. We show the overall results for eight separate reform paths. Specifically we have a more modest and more aggressive reform plan for each of the goals (change in average performance and improvement at the bottom end). We also in each instance consider a 20-year and a 10-year reform path.

The most modest reform plan would call for improving average performance by 25 points (PISA equivalent) or one-quarter standard deviation, and it would do this improvement over a 20 year period. As Table 2, this “modest” reform would yield additions to GDP over the next 80 years that were worth over 300 percent of current GDP. An aggressive program of 50 point improvement over 20 years would have a present value of 664 percent of current GDP.
The programs of improvement at the bottom end of the achievement distribution also have large gains in the economy. A 20 percent improvement in the proportion of students reaching level 1 (i.e., reaching 400 PISA points) would yield higher GDP equal to 342 percent of current GDP even with a 20 year reform program. With a 10-year reform, the gains would be over four times current GDP.

Table 2 also suggests how long run growth will change with improved achievement. At the low end of the table, a 25-point improvement in scores will lead to $\frac{1}{2}$ percent higher annual growth—an enormous amount when compounded over the lifetime of somebody born today. 

(Hanushek & Woessmann, 2011)

**Real GDP per capita growth induced by USL 1 over the next half a century**

Please note that the USA per Capita GDP (PPP) increased roughly 3 times over half a century, but at the current rate Real GDP per capita rate of now (about 1.5%) will only 2x over the next 50 years. Now, consider that Real GDP per capita induced by USL 1 will roughly halve the doubling time. So even with the very conservative estimates of Hanushek-Woessmann, it will 3.5x-4x, and with the very rapid USL 1 reforms, it will 5x-6x larger than now.

![Graph showing growth of per capita GDP](image)

Source: CISCO

**EXPENDITURES ON (INTER-)NATIONAL MATH EDUCATION**

The OECD total GDP is about 50 Trillion US$ annually as of 2014-2015. So 230 billion USD annually is about 0.5% of their entire GDP. The U.S.A. spend even more money than most of other OECD countries. This 0.5% is only the public spending. So if you estimate the entire K-12 expenditures on math education, including all the private expenditures, tutoring etc., we can easily estimate this to be about 0.7-1% of GDP, edging to half a trillion USD annually. With this much money spent, how are the OECD countries progressing in their national school math tests in cross-country math assessments?
Annualized progress of math proficiency (international and national)

In this section, we can see that over the past 15 years or so, the NAEP data reveal that the U.S.A. average school math levels have progressed at the ratio that 1 year national average math progress takes 15-16 years. According to PISA growth rate (2003-2012), however, the U.S. school math will advance 1 year needs many decades to reach. Let’s start with the NAEP results first.

‘Comparisons across Countries

Let us first consider in absolute terms the overall gains on NAEP that provide the benchmark against which every state and all foreign jurisdictions are compared. Americans will be pleased to learn that the performance of U.S. students in 4th and 8th grade in math, reading, and science improved noticeably between 1995 and 2009. Using information from all administrations of NAEP tests to students in all three subjects over this time period, we observe that student achievement in the United States is estimated to have increased by 1.6 percent of a standard deviation (std. dev.) per year, on average. Over the 14 years, these gains equate to 22 percent of a std. dev. (Peterson, Woessmann, & Hanushek, Achievement Growth: International and U.S. State Trends, 2012)

The average U.S. school math proficiency growth rates
The U.S. states’ test scores vs. their growth rates in terms of test scores and the Real GDP growth rates

Please note that the average growth rates of the U.S.A. states are about 1.6%, but as the average of states progress their annual math score gains slow down. This is a snapshot of the link between the advancing test scores such as school math vs. the Real GDP growth rates.
The overall annual rate of growths in student achievement in math chart (the U.S.A.)
The overall annual rate of growths in student achievement in math for the 4th and 8th grades are listed below.

Annualized progress of math scores: international (in PISA)
In PISA math, 50 points roughly correspond to 1 year school math difference in average. If you look at the PISA 2012, at least for PISA, the majority of countries have deteriorated and the U.S.A. progressed at the rate that will take half a century to reach 50 extra points (which is equivalent to progress with the national math by about 1 year) of PISA in math. This is much worse than NAEP’s average math scores progress in the U.S. math, which will take about 15-16 years to gain 1 year level math nationwide.

Source: PISA 2012 Results in Focus: What 15-year-olds know and what they can do with what they know
(OECD-PISA, 2014)

The close cross-country correlation between average PISA and TIMSS test scores
The USL1 tries to collaborate with international math assessments in near future. In this chart, we can see there is a close correlation between the test scores of PISA and TIMSS for instance.
The U.S.A. state level of math proficiency chart
You can find where your state level of math proficiency belongs in the following table.

Table 1

Percentages of all students in the class of 2011 at the proficient level in math per state. Foreign jurisdictions with similar and higher percentages at the proficient level in math in overall student population.

<table>
<thead>
<tr>
<th>State</th>
<th>Percent proficient</th>
<th>Significantly outperformed by*</th>
<th>Countries with similar percentages of proficient students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td>50.7</td>
<td>6</td>
<td>Canada • Japan • Netherlands • New Zealand • Switzerland</td>
</tr>
<tr>
<td>Minnesota</td>
<td>43.1</td>
<td>11</td>
<td>Australia • Belgium • France • Germany • Netherlands</td>
</tr>
<tr>
<td>Vermont</td>
<td>41.4</td>
<td>14</td>
<td>Australia • Denmark • Estonia • France • Germany</td>
</tr>
<tr>
<td>North Dakota</td>
<td>41.0</td>
<td>16</td>
<td>Denmark • Estonia • France • Iceland</td>
</tr>
<tr>
<td>New Jersey</td>
<td>40.4</td>
<td>14</td>
<td>Australia • Austria • Denmark • France • Germany</td>
</tr>
<tr>
<td>Kansas</td>
<td>40.2</td>
<td>16</td>
<td>Austria • Denmark • Estonia • France • Slovenia</td>
</tr>
<tr>
<td>South Dakota</td>
<td>39.1</td>
<td>16</td>
<td>Austria • Denmark • France • Hungary • Sweden</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>36.3</td>
<td>10</td>
<td>Austria • Denmark • France • Hungary • Sweden</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>37.5</td>
<td>18</td>
<td>Austria • Denmark • France • Hungary • Sweden</td>
</tr>
<tr>
<td>Montana</td>
<td>37.6</td>
<td>18</td>
<td>Austria • France • Hungary • Poland • Sweden</td>
</tr>
<tr>
<td>Virginia</td>
<td>37.5</td>
<td>17</td>
<td>Czech Rep • France • Hungary • Poland • Sweden</td>
</tr>
<tr>
<td>Colorado</td>
<td>37.4</td>
<td>18</td>
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</tr>
<tr>
<td>Wisconsin</td>
<td>37.0</td>
<td>18</td>
<td>Czech Rep • France • Hungary • Poland • Sweden</td>
</tr>
<tr>
<td>Maryland</td>
<td>36.5</td>
<td>18</td>
<td>Czech Rep • France • Hungary • Poland • U.K.</td>
</tr>
<tr>
<td>Wyoming</td>
<td>36.0</td>
<td>18</td>
<td>Czech Rep • France • Hungary • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>Washington</td>
<td>35.9</td>
<td>19</td>
<td>Czech Rep • France • Hungary • Poland • U.K.</td>
</tr>
<tr>
<td>Ohio</td>
<td>35.4</td>
<td>18</td>
<td>Czech Rep • France • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>Iowa</td>
<td>35.2</td>
<td>19</td>
<td>Czech Rep • France • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>Indiana</td>
<td>35.1</td>
<td>19</td>
<td>Czech Rep • France • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>Oregon</td>
<td>34.8</td>
<td>20</td>
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<tr>
<td>Connecticut</td>
<td>34.7</td>
<td>19</td>
<td>France • Poland • Portugal • Spain • U.K.</td>
</tr>
<tr>
<td>Texas</td>
<td>34.7</td>
<td>21</td>
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</tr>
<tr>
<td>Nebraska</td>
<td>34.6</td>
<td>20</td>
<td>Czech Rep • Hungary • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>North Carolina</td>
<td>34.5</td>
<td>21</td>
<td>Czech Rep • Hungary • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>Maine</td>
<td>34.1</td>
<td>22</td>
<td>Czech Rep • Hungary • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>Idaho</td>
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<td>22</td>
<td>Czech Rep • Hungary • Poland • Portugal • U.K.</td>
</tr>
<tr>
<td>Utah</td>
<td>32.4</td>
<td>26</td>
<td>Italy • Poland • Portugal • Spain • U.K.</td>
</tr>
</tbody>
</table>
USL 0.5 is designed to push the average OECD or U.S.A. math scores to boost about Canada level, which corresponds to the added annual Real GDP growth of about 1%.

Some critical quotes by Hanushek-Woessmann-Peterson relevant for the USL 0.5 and 1.0 to your government
Excerpts from ‘Achievement Growth: International and U.S. State Trends in Student Performance’

‘Using information from all administrations of NAEP tests to students in all three subjects over this time period, we observe that student achievement in the United States is estimated to have increased by 1.6 percent of a standard deviation (std. dev.) per year, on average. Over the 14 years, these gains equate to 22 percent of a std. dev. When interpreted in years of schooling, these gains are notable. On most measures of student performance, student growth is typically about 1 full std. dev. on standardized tests between 4th and 8th grade, or about 25 percent of a std. dev. from one grade to the next. Taking that as the benchmark, we can say that the rate of gain over the 14 years has been just short of the equivalent of one additional year’s worth of learning among students in their middle years of schooling.’

‘Our findings come from assessments of performance in math, science, and reading of representative samples in particular political jurisdictions of students who at the time of testing were in 4th or 8th grade or were roughly ages 9–10 or 14–15. Most measures of student performance, student growth is typically about 1 full std. dev. on standardized tests between 4th and 8th grade, or about 25 percent of a std. dev. from one grade to the next. Taking that as the benchmark, we can say that the rate of gain over the 14 years has been just short of the equivalent of one additional year’s worth of learning among students in their middle years of schooling.’


‘Cumulative growth rates vary widely. Average student gains over the 19-year period in Maryland, Florida, Delaware, and Massachusetts, with annual growth rates of 3.1 to 3.3 percent of a std. dev., yielded gains of some 59 percent to 63 percent of a std. dev. over the entire time period, or better than two years of additional learning. Meanwhile, annual gains in the states with the weakest growth rates—Iowa, Maine, Oklahoma, and Wisconsin—varied between 0.7 percent and 1.0 percent of a std. dev., which translate over the 19-year period into learning gains of one-half to three-quarters of a year. In other words, the states making the largest gains are improving at a rate two to three times the rate in states with the smallest gains.’

The key Hanushek-Peterson-Woessmann papers from OECD, World Bank, UNESCO (UN), and Harvard relevant for USL 0.5 & 1

For more confirmations relevant for the USL1 claims, please check the following from OECD, World Bank, UNESCO (UN), and Harvard. You can view them all online.

Hanushek-Woessmann papers from World Bank:


Hanushek-Woessmann papers from OECD:


Hanushek-Woessmann papers from UNESCO (Global Monitoring Report 2012):


Hanushek-Woessmann-Peterson papers from Harvard’s Program on Education Policy and Governance & Education Next Taubman Center for State and Local Government Harvard Kennedy School

http://www.hks.harvard.edu/pepg/PDF/Papers/PEPG12-03_CatchingUp.pdf


CONCLUSION

USL x.x series are not only designed to bring the largest STEM education storms since the 19th century, but also to bring the colossal GDP growths as well as the massive social changes. USL 0.25, 0.5, and 1.0 series are the first steps to boost the city, state, and then national level school math in mere a few years although they normally takes decades. This paper will function more like an Appendix 1 of USL 0.5 or 1.0 and some other sequel papers will be released.

References (Hanushek-Woessmann-Peterson)


References (non Hanushek-Woessmann-Peterson)
