A Mathematics Problem:

How to Help Students Achieve Success in Mathematics Through College and Beyond

by MetaMetrics President and Co-founder Malbert Smith III, Ph.D., and Director of Professional Development Jason Turner

When it comes to our students' performance in mathematics, there is cause for concern. According to the results of the 2009 Programme for International Student Assessment (PISA), U.S. students ranked a dismal 25th out of 35 countries (OECD Programme for International Student Assessment (PISA), 2009). A 2009 National Center for Education Statistics report that compared the performance of U.S. 15-year-olds with their peers in OECD (Organisation for Economic Co-operation and Development) countries stated that U.S. students ranked in the bottom quarter of participating countries in mathematics (National Center for Education Statistics, 2009).

Reinforcing these findings is past U.S. students' performance on the ACT. Only 25 percent of graduates who took the ACT in 2007 achieved the college readiness benchmark in mathematics (ACT, 2008). And while 2011 NAEP results show a slight increase in students' mathematics performance, only about one-third of eighth-grade U.S. students achieved the proficiency level (National Assessment of Educational Progress, 2011). These trends point to a simple truth: many U.S. students graduate unprepared for the challenges they will likely face in college and careers. This unpreparedness not only portends significant academic challenges, but increasingly dire consequences at both the individual- and macro-economic levels. At the individual level, students may find themselves unable to compete academically and miss out on employment opportunities in some of today's fastest growing career sectors.

At the macro level, poor mathematics performance suggests an alarming outlook for our country's competitiveness in the international arena. In response to the 2009 NCES report, Education Secretary Arne Duncan said, "We are lagging the rest of the world, and we are lagging it in pretty substantial ways. I think we have become complacent. We've sort of lost our way" (Holland, 2009). Secretary Duncan's observation is bolstered by the fact that a growing number of STEM (science, technology, engineering and mathematics) doctoral students matriculate from outside the U.S. Many STEM graduate students attend American universities and then return to their native countries, leaving the U.S. with a shortage of graduates prepared for STEM-related fields. Furthermore, the National Science Board's "Science and Engineering Indicators: 2010" report stated that only 15.6 percent of bachelor's degrees were awarded in STEM fields (Business Higher Education Forum).

Reversing these trends can have a positive impact on our nation's economy. An OECD study predicted that an increase of 25 points on the PISA over the next 20 years would result in an economic gain of $41 trillion for the U.S. economy—an economic advantage our country may never see without a substantial effort to increase the mathematics and science abilities our students (Armario, 2010).

The Common Core State Standards movement was fueled by the recognition that our country needs to adhere to a set of clearly articulated standards of sufficient rigor to ensure all students graduate college- and career-ready. The Mathematics Standards establish a clear pathway of courses that students must complete, including Algebra I, Geometry, Algebra II, and possibly a higher-level course for seniors. They describe understanding and using Algebra II skills and concepts as the minimum level for college- and career-readiness.

Unfortunately, as evidenced by the various benchmarks mentioned earlier, a large percentage of U.S. students are deficient in mathematics. The degree to which these math deficiencies will be eliminated depends in large part on the success of the Common Core. As districts and schools move from adopting the Standards to the more difficult phase of implementing them, it is imperative that publishers provide

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curriculum tools and resources that support classroom teachers. And while implementation of the Standards is the necessary first step, we must also address some of the core reasons why our students struggle with mathematics. The reasons are multi-faceted and complex, but several stand out.

Why Do American Students Struggle With Mathematics?

First, educators often struggle to overcome their students' "math bias." Well-meaning parents may unknowingly magnify this bias with their own anxiety toward mathematics. Marilyn Burns, a highly respected mathematics educator, has argued that two-thirds of American parents have a deep phobia of mathematics (Burns, 1998). While there is some evidence that certain basic mathematical abilities (like approximation) are inborn, there is also overwhelming evidence that mathematical ability is no more innate than literacy (Butterworth, 2006). It is almost unthinkable to imagine a parent or educator speaking of literacy as if it were a genetic trait and dismissing struggling readers as simply not possessing the 'reading gene'. Viewing mathematics as a skill that is learned through intensive and distributed practice will go a long way in improving our students' mathematics performance.

Second, mathematics tends to be the neglected of the three R's (reading, writing and arithmetic)—receiving far less academic attention than literacy. NCES reported this year that 47 percent of fourth-grade educators said they spent ten or more hours per week on English language arts. No educators reported spending equal time on mathematics and only 29 percent reported spending seven hours or more per week on mathematics instruction (National Assessment of Educational Progress, 2011). Constrained by budgets, time and instructional resources, many districts focus their efforts on literacy initiatives. Instructional differences between literacy and mathematics—and a lack of targeted resources—limit many districts from being able to keep students engaged in mathematics activity year-round.

Third, most classrooms, particularly in elementary and middle schools, represent a heterogeneous mix of mathematical abilities—from students who perform above grade level to those who struggle to meet grade-level expectations. Differentiating reading instruction is commonplace, but targeted learning in mathematics is far less common. And while ample professional development opportunities exist for differentiating for the struggling reader, there are fewer opportunities available for mathematics educators. As they attempt to shift from whole-class instruction to differentiating for the various skill levels in their classrooms, many educators find a vexing challenge in differentiating content for such a diverse range of mathematical abilities, and struggling students are most at risk of being left behind.

The fourth challenge in improving students' mathematics performance is the pernicious effect of summer learning loss, which has complicated efforts to maintain student trajectories toward college- and career-readiness. For many students, a break in the school year means a cessation of most, if not all, academic activity; and those students return to school in the fall with their mathematical abilities diminished from just a few months earlier. This loss has been well documented, and many education reformers now consider fighting summer learning loss an important part of any serious education reform agenda (Cooper, 1996).

Low-income students, generally, are more susceptible to summer reading loss. But, in mathematics, all students suffer from learning loss, regardless of their socio-economic level (Entwistle, 1992). All states offer some type of summer reading program, but far fewer have an analog for mathematics. Admittedly, keeping students engaged in meaningful mathematical activities during the summer presents more challenges than most reading programs. For example, while many students can read independently, far fewer are comfortable engaging in mathematics on their own. And attempts to do so are further complicated by a lack of access to targeted mathematics resources.

While it is easy to dismiss summer loss as a fact of academic life, the consequences are profound. The learning loss that occurs over twelve consecutive summers results in a significant achievement gap between those who are prepared for the rigors of college and careers and those who are not. How do we combat the mathematical deficiencies that students face? And how do we prepare every student for the demands of the postsecondary world?

A Common, Developmental Scale

The first step to helping educators improve students' mathematical achievement levels is to make available tools that allow them to evaluate readiness. Mathematical achievement and the difficulty of skills and concepts should be measured

on a common scale. This allows educators to monitor growth toward college- and career-readiness, as well as to identify the gap between a student's level and the level of the mathematics content being taught at that grade level (Figure 1 illustrates the typical Quantile® ranges for students from kindergarten through Algebra II). Similar to how The Lexile® Framework for Reading measures readers and texts on the same scale, The Quantile Framework for Mathematics measures achievement and the difficulty of mathematical skills and concepts (including the new Common Core Mathematics Standards) on the same scale. Armed with this information, educators can more precisely identify the gap between a student's level and the difficulty of specific tasks to help guide classroom instruction (Figure 2 on the following page illustrates the mathematics curricular demand continuum as students progress from elementary through high school).

Figure 1: Typical Grade Ranges for Students' Quantile and Lexile Measures

Grade	Quantile Measures (Interquartile[1] Range, Mid-Year)	Lexile Measures (Interquartile[1] Range, Mid-Year)
K–1	EM* (0Q and below)	Up to 300L
2	100Q to 480Q	140L to 500L
3	340Q to 660Q	330L to 700L
4	495Q to 815Q	445L to 810L
5	635Q to 955Q	565L to 910L
6	700Q to 1020Q	665L to 1000L
7	750Q to 1070Q	735L to 1065L
8	820Q to 1140Q	805L to 1100L
9 (Algebra)	870Q to 1190Q	855L to 1165L
10 (Geometry)	940Q to 1260Q	905L to 1195L
11 (Algebra II)	1000Q to 1320Q	940L to 1210L**

*Emerging Mathematician **Grades 11 and 12

[1]Interquartile is the range between the upper and lower quartiles (i.e., the middle 50 percent of a distribution) and is equal to the difference between the 75th and 25th percentile.

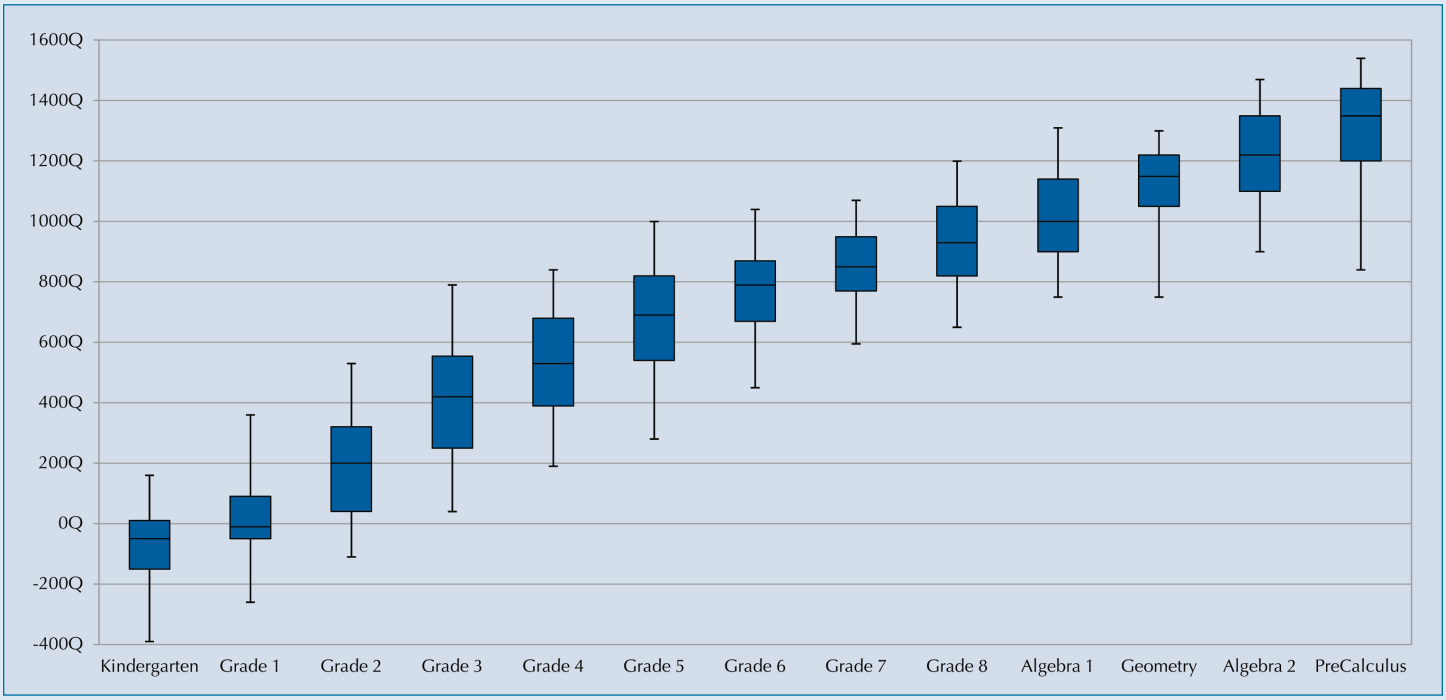
Differentiating Mathematics Instruction

The second step to improving student readiness is to provide educators with resources for more effective differentiation, particularly for struggling students. The Association for Supervision and Curriculum Development (ASCD) describes differentiated instruction as a means of creating multiple paths so that students of varying abilities, interests and learning needs experience equally appropriate ways to absorb, use, develop and present concepts as a part of the daily learning process (Development, 2009). In order to prepare students for success in and out of the classroom, educators must differentiate the mathematics curriculum to meet the needs of all learners—by remediating or accelerating instruction, when necessary, and providing students with opportunities to learn and grow (Smith, 2010). In typical classroom environments comprised of varying ability levels, the Quantile Framework allows educators to harness the power of a common scale and metric to differentiate instruction and transition from whole-class instruction to targeting struggling students, and even offer enrichment activities for those students who have mastered previous mathematical skills and concepts.

By establishing the demand (difficulty) measure of hundreds of mathematical skills and concepts, MetaMetrics® has identified 'knowledge clusters'. The knowledge cluster for any particular skill or concept is comprised of the specific prerequisite skills that precede the skill in consideration. These knowledge clusters not only illustrate the interconnectivity of the skills and concepts, but also provide educators with actionable information they can use to target instruction, forecast understanding and address student achievement. Inexperienced mathematics teachers often lack the tools for identifying the specific gaps in student learning or the areas where a student may be deficient, making efforts to differentiate mathematics content a Herculean task. By utilizing descriptive knowledge clusters, the Quantile Framework allows educators to not only identify the gap between the learner and skill to be taught, but enables meaningful targeting by providing the appropriate prerequisite material.

To aid educators in differentiating mathematics instruction, MetaMetrics provides two free, online instructional tools for accessing the knowledge clusters: the Math Skills Database and the Quantile Teacher Assistant. Both utilities deliver online access to each knowledge cluster and can be accessed through each state standard, including the Common Core State Standards, which have already been aligned with the Quantile Framework. For any specific skill, an educator can access not only the appropriate prerequisite skills, but a host of free resources, including video tutorials, task suggestions, group activities, literature guides, online activities and supplemental skill sheets, which have been calibrated to the Quantile scale. These online tools and resources support differentiation by allowing educators to use a student's Quantile measure to match that student with relevant prerequisite skills and address specific gaps in learning. Best of all, educators can then address those gaps with targeted math resources as a means to mitigate a student's deficiencies.

Figure 2: Typical Grade Ranges for Students' Quantile Measures



Increasing Instructional Time

As mentioned earlier, a third critical step in narrowing the gap between students' mathematical levels and college- and career-readiness is reducing the amount of mathematics learning loss that occurs each summer through increased instructional time and mathematics engagement. Extending mathematics engagement may be achieved in a variety of ways, including the provision of targeted resources—resources which supplement and reinforce the skills and concepts acquired during the school year. In mathematics, especially, attempts to curb the effects of learning loss must rely on keeping students engaged in meaningful year-round mathematics activity. Because mathematics most often requires instructional assistance in order to learn new skills and concepts, engagement, in this sense, may simply mean committing to activities and resources which reinforce and supplement last year's lessons. Logistical difficulties and technology concerns have previously made mathematics engagement during the summer months a near impossible task. Advances in technology, however, have put meaningful math programs within reach, and school districts should be challenged to take steps toward addressing the well-documented effects of summer learning loss.

MetaMetrics' free Math@Home is one online tool that allows students to access targeted mathematical content beyond the confines of the classroom. Math@Home provides students with targeted resources, like websites, worksheets, video tutorials, and skill sheets, that support the textbook lessons studied throughout the year. Additionally, Math@Home harnesses the power of prominent social networking features to allow students and teachers to share multiple resource lists with other users.

Conclusion

It is imperative that students graduate adequately prepared for the academic and career challenges that await them. As policy makers search for ways to ensure robust opportunities for individual citizens and that the U.S. retain its global competitiveness and economic health, it is critical that educators have the tools necessary to measure student growth and cross-reference that growth against a standard of real-world preparedness.

By utilizing a common scale—along with the technology and resources that support its application—educators will finally have the tools to differentiate for both struggling and striving learners and ensure that they are on a path toward college- and career-readiness.

As a country, we are embarking on a new and exciting period in which 47 states have voluntarily adopted the Common Core. The real litmus test for how well we can raise our students' mathematical achievement levels rests upon trans-

lating the new Standards into actionable tools for educators, parents and students. At MetaMetrics, we are breathing life into the Standards by providing practical and freely available instructional resources based on the Quantile Framework. While the Common Core provides a clear road map to college- and career-readiness on a macro level, our work will better enable educators to apply the Standards at a micro level as they provide students with the targeted instruction needed to prepare for the challenges of the postsecondary world.

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ABOUT THE AUTHORS: Malbert Smith III, Ph.D., is president of MetaMetrics®, an educational measurement and research organization. Together with co-founder and CEO A. Jackson Stenner, Ph.D., Dr. Smith created The Lexile® Framework for Reading; El Sistema Lexile para Leer; The Lexile Framework for Writing; and The Quantile® Framework for Mathematics. Dr. Smith strives to make educational measurement actionable in the classroom and at home. His vision of common metrics for reading, writing and mathematics opens the way for differentiated instruction. In each state—and increasingly abroad—educators use Lexile and Quantile measures to blend instruction and assessment in whole-class and intervention settings. Concerned with the relationship between early literacy and college- and career-readiness, Dr. Smith led research to build a continuum of text complexity that places academic and life goals on the Lexile scale. He and Dr. Stenner were members of the team that contributed to the Common Core State Standards. They are also senior investigators on a National Center for Education Statistics research study to examine NAEP benchmark scores in relationship to college- and career- readiness. Dr. Smith serves on the UNC School of Education Foundation Board, the advisory board of Capstone Digital, and is a member of the advisory board for EdSteps, a joint project of the Council of Chief State School Officers and The Bill and Melinda Gates Foundation. He and Dr. Stenner are leading a three-year grant from The Gates Foundation on the efficacy of personalized learning platforms. Dr. Smith is a member of The American Association for the Advancement of Science, The American Educational Research Association and The National Council on Measurement in Education. He has taught graduate seminars in educational research and test development and design at Duke University and the University of North Carolina at Chapel Hill, from which he received the Distinguished Alumni Award. Dr. Smith frequently speaks at various events on educational research and measurement.

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METAMETRICS® POLICY BRIEFS: MetaMetrics is focused on improving education for learners of all ages. For over twenty years, our work has been increasingly recognized for its distinct value in differentiating instruction and personalizing learning. Our research on postsecondary reading demands, for example, informed the Common Core State Standards for college- and career-readiness. In addition to the white papers and position papers we publish throughout the year, our policy briefs will encompass our research on a variety of educational issues, such as closing the achievement gap, next-generation assessments, and college and career readiness. The policy briefs will explore potential ways to address these critical issues by focusing on education as the foundation of student success and the stepping stone to social and economic growth in our country.

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