Legislative Research Commission

Office of Education Accountability

Mathematics Study
Part 1: Assessment and Course Taking

Research Report No. 369 Part 1

Prepared by

Marcia Ford Seiler, Director; Brenda Landy; Ken Chilton, Ph.D.; Al Alexander; Deborah Nelson, Ph.D.; Sabrina Olds; Brad Parke; Keith White, Ph.D.; and Pam Young

Mathematics Study
Part 1: Assessment and Course Taking

Project Staff

Marcia Ford Seiler, Director
Brenda Landy
Ken Chilton, Ph.D.
Al Alexander
Deborah Nelson, Ph.D.
Sabrina Olds
Brad Parke
Keith White, Ph.D.
Pam Young

Research Report No. 369

Legislative Research Commission
Frankfort, Kentucky
lrc.ky.gov

Accepted December 7, 2009, by the
Education Assessment and Accountability Review Subcommittee

Paid for with state funds. Available in alternative form by request.

Foreword

In December 2008, the Education Assessment and Accountability Review Subcommittee directed the Office of Education Accountability to undertake a three-part review of mathematics performance in Kentucky schools. This report is presented in three parts. Part 1 focuses on student assessment and evaluation data and trends. It sets a broader context for Part 2 and Part 3 of the mathematics study.

The Office of Education Accountability would like to thank the staff of the Kentucky Department of Education and the Council on Postsecondary Education for their assistance in completing this report.

Robert Sherman
Director

Legislative Research Commission
Frankfort, Kentucky
December 2009

Contents

List of Tables

List of Figures

Summary

The past three decades have seen state and national calls to improve education in science, technology, engineering, and mathematics (STEM). At a time when STEM skills are increasingly needed in order to compete in a global economy, national leadership in these fields appears to be eroding. The ability to compete in a global economy may affect Kentucky even harder than other states because the Commonwealth is significantly behind many other states with respect to STEM skills and employment.

Among all of the STEM disciplines, mathematics is particularly important as a gateway skill for success in other areas. For this reason, the Office of Education Accountability, at the direction of the Education Assessment and Accountability Review Subcommittee, undertook a comprehensive study of mathematics in Kentucky. The study was designed to be conducted in three parts: mathematics assessment and course taking, teacher quality, and improvement effort in schools and districts. This report, Part 1, makes seven recommendations regarding mathematics assessments, course taking, and graduation requirements.

Data Needs for Evaluating Initiatives

Accurate, timely, and consistent data are crucial for research and evaluation. State-specific research and evaluation depend heavily on data collected and maintained by state agencies. There is an overarching need for better oversight and governance of data collected and reported by the Education Professionals Standards Board, the Council on Postsecondary Education, and the Kentucky Department of Education. This is especially critical given upcoming changes to Kentucky's high school graduation requirements and assessments, as well as efforts to develop a P-20 data system that will integrate education data from preschool through higher education.

Recommendation 1.1
The Council on Postsecondary Education, the Education Professional Standards Board, and the Kentucky Department of Education should have in place adequate methods of review and audit to ensure that the data they collect and maintain contribute to a comprehensive P-20 database for use by the public and researchers.

Recommendation 3.1
The Kentucky Department of Education should collect student-level data on courses taken, transcripts, and grades. The department should analyze the impact of new graduation requirements, determine whether schools are achieving desired goals, and provide districts with specific guidance and support to ensure that courses cover the expected content with sufficient rigor.

Assessments of Mathematics Knowledge and Skills

Assessment data show that Kentucky students' mathematics knowledge and skills have been improving over time but are still at levels below the national average. It is of great concern that college-readiness exams indicate Kentucky's high school graduates are not ready for postsecondary education and careers of today, much less for the increasing demands of

tomorrow's workplace. Achievement gaps are substantial with respect to income, race, English language proficiency, and disability.

This report does not make recommendations regarding assessments because Kentucky is already working with other states, the National Governors Association, and the Council of Chief State School Officers to develop common standards, which will result in substantial changes to Kentucky's assessment and accountability system. Even after these changes are made, the results of past assessments will continue to provide a historical record of the Commonwealth's progress.

Relationship Between Course Taking and Achievement

Students who take demanding mathematics courses have higher average achievement and college-readiness test scores than those who do not, even after controlling for such factors as prior student achievement and socioeconomic status. It stands to reason that demanding courses offer more advanced learning opportunities. However, test score differences also reflect some self-selection. Students who currently take demanding courses do so voluntarily, and they tend to have stronger skills to begin with. National trends show that as more students take these courses and more levels of ability are represented, the average test scores associated with these mathematics courses decline somewhat.

Another factor contributing to national declines in test scores associated with advanced mathematics courses could be that as more students take these courses, some educators lower standards to accommodate the wider range of student abilities. Currently, Kentucky has few safeguards to ensure that students receive the same opportunities to learn. The content of an Algebra I course can vary from district to district, from school to school within a district, and from classroom to classroom within a school. There is little monitoring, feedback, and enforcement to ensure that students are taking courses that truly cover the content required by the program of studies and high school graduation requirements.

Although students with a wide range of abilities can benefit from taking demanding courses, research shows that a small proportion of the most struggling students have worse test scores when they take advanced mathematics. This suggests that students who are already struggling to meet minimum requirements might be better served by courses in which they have a chance to master the concepts instead of courses in which they might be confused and discouraged. In fact, most states that are raising graduation requirements are creating a "default" system of requirements that set high expectations but that also provide a process by which students may opt for less-demanding courses once they and their parents have been fully briefed on the potential consequences.

Although taking more-demanding high school courses is associated with higher test scores, research finds that learning in earlier grades is even more strongly associated with test scores than is high school course taking. Therefore, earlier intervention may prove more productive than waiting until high school to help struggling students.

Recommendation 3.2
The Kentucky Department of Education should ensure that the grade-by-grade standards and curricula currently being developed give students strong early foundations in mathematics so that they will be ready to meet the high school graduation requirements and succeed in mandated assessments.

Recommendation 3.3
The Kentucky Department of Education should require that all data reported by schools and districts and collected by the department are accurate and compliant with departmental requirements. By June 1, 2010, the department should provide districts with a thorough course code listing with sufficient guidance and detail for the content that should be taught in each course. The department should require that districts use the course codes when reporting data beginning in the 2011 school year and should annually audit and review reported data for compliance.

End-of-course assessments offer one potential solution for ensuring consistent and rigorous course content. On completion of a course, students would take a standardized exam—preferably, one developed by a multistate consortium. Results of the test could be compared to state standards and to the performance of all Kentucky students and students in other states.

In 2006, House Bill 197 established a pilot program to develop end-of-course exams for Algebra I, Algebra II, and Geometry. So far, student performance has been low on these pilots.

Recommendation 3.4
The Kentucky Department of Education should evaluate the outcomes of the end-of-course pilot initiatives and determine the effectiveness of the tests. The department should determine whether the use of end-of-course assessments is an effective means of ensuring that all students receive similar content and rigor in comparable courses. If such pilot programs prove effective, the department should inform the Education Assessment and Accountability Review Subcommittee of these outcomes and of the plans and costs associated with statewide implementation of such a program for various courses.

Lessons Learned by Other States That Increased Graduation Requirements

With Kentucky poised to increase graduation requirements for the class of 2012, it would be helpful to learn from others' experiences with such changes.

Need for Additional Support. Chicago Public Schools found that increasing graduation requirements is most successful at boosting achievement when student and school support is provided. Examples include the development of new curricular materials that introduce students to algebra concepts in grades K-8, requiring struggling 9th graders to take double periods of algebra, providing separate classes for high-ability students, and providing middle school and high school teachers with more professional development.

Tailoring Instruction to Different Levels of Ability. Meeting new, more challenging graduation requirements will be more difficult for some students than for others. The National Education Longitudinal Study found that having three separate classes for 8th graders with low, medium, and high ability produces the most progress in algebra. For courses other than algebra, the optimum appears to be two levels, one for high-ability students and one for all other students. Grouping students by ability may raise the specter of stigmatizing by "tracking," a discredited practice that permanently labeled some students as "slow learners" and offered these students fewer learning opportunities. In contrast, ability grouping is meant to offer all students the same content, covered at a pace tailored to students' abilities to absorb the materials. Currently, Algebra I and Algebra II can be taught as 2-year courses for students who need extra time; as 1-year courses for students of medium ability; and as accelerated, honors, or college-preparation courses for high-ability students.

Cost Implications. When regulatory changes were proposed to add Algebra II to Kentucky's high school graduation requirements, the regulatory impact analysis provided by Kentucky's acting education commissioner anticipated minimal fiscal impact. However, other states expect substantial impact by needing more teachers, classrooms, textbooks, remedial services, and departmental staff. A 2008 cost analysis for the Connecticut State Department of Education also anticipated the need for more departmental staff to guide districts in implementing the new requirements and to collect and maintain data for monitoring and evaluating compliance. Budget constraints have caused some states to delay changes to graduation requirements.

Implications for Middle and Elementary School Instruction and Curricula. Raising high school graduation requirements has ramifications for all grades. Anticipating that students might need more than 4 years to fulfill new Algebra II requirements, some states require the completion of Algebra I by the end of 8th grade. The National Mathematics Advisory Panel calls for a more logical progression through foundational mathematics, particularly in whole numbers, fractions, geometry, and measurement. The panel emphasizes younger students' need for an array of challenging instruction. Like language, mathematics requires considerable practice to gain fluency so that students are ready to take on more complex concepts.

Recommendation 3.5
The Kentucky Department of Education should ensure that program review and outcome evaluation plans are developed, carried out, and reported for each initiative to improve student achievement.

Chapter 1

Introduction

The past 3 decades have seen repeated state and national calls to improve science, technology, engineering, and mathematics (STEM) education.

The past 3 decades have seen repeated state and national calls to improve education in science, technology, engineering, and mathematics (STEM). The 1983 report *A Nation at Risk* warned that a "rising tide of mediocrity" in US education was eroding the foundations of the country's prosperity, security, and civility (Natl. Commission on Excellence). Not all agree with the report's conclusions and the reforms that followed, but most agree that improvements in student achievement have been slow and uneven since the report was published. Consequently, more reports have followed, calling for reforms at the K-12 and higher education levels (American; Natl. Commission on Mathematics; Natl. Academy; Natl. Mathematics).

Even as STEM skills are increasingly needed, US leadership in STEM appears to be waning.

A key impetus for reform is the perception that, at a time when STEM skills are increasingly needed, US leadership in STEM fields is waning. The ability to compete in a global economy may affect Kentucky more than other states because the Commonwealth is significantly behind many other states with respect to STEM skills.

Increasing Need for Mathematics in the Workplace

Most of the best-paying and some of the fastest-growing fields require advanced mathematics skills. Even non-STEM jobs require more math knowledge than in the past.

Mathematical knowledge and skills are increasingly important for employment opportunities and a high standard of living; many jobs require more mathematical knowledge and skills than they did in the past, with workers expected to analyze a problem, determine its causes, and devise creative new solutions (Council). According to the Bureau of Labor Statistics, most of the fastest-growing and best-paying fields require advanced mathematics skills (US. Dept. of Labor. Bureau. BLS Releases, "STEM," and "Tomorrow's"). At the same time, wages and job opportunities for lesser-skilled workers have stagnated, and employers are increasingly outsourcing to inexpensive labor in other countries (Greenspan).

Mathematical knowledge and skills are becoming more important for economic growth.

In addition to benefits for individuals, mathematics skills have benefits for the economy; numerous studies have linked mathematical skills to higher productivity and economic growth (Greenspan; Natl. Governors. *Benchmarking*).

It should be noted that not everyone agrees that student achievement is related to global competitiveness; some point out that the US economy continues to outperform many countries that have higher student achievement (Bracey; Ramirez).

Shrinking US Global Leadership

US students trail students from many other countries on international assessments.

On international assessments, US students trail behind those in many other countries. On the 2007 Trends in International Mathematics and Science Study (TIMSS) assessment, the US ranked 11th out of 36 countries on the grade 4 test, and 9th out of 48 countries on the grade 8 test. However, between 1995 and 2007, US student performance showed significant gains at both grade levels (US. Dept. of Ed. Inst. Natl. *US Performance* 18-25).

The mathematical literacy measures in the Program for International Student Assessment (PISA) tell a more troubling story. In 2006, the math performance of US 15-year-olds ranked 35th out of 57 countries, and performance did not improve significantly between 2003 and 2006 (US. Dept. of Ed. Inst. Natl. *US Performance* 26-31).

The number of degrees annually conferred in the STEM areas is down in the US, and many countries are competing for skilled foreign workers with STEM competencies.

At the higher education level, the number of college students pursuing degrees in the STEM areas declined in the 1990s and early 2000s. In the past few years, the number of science degrees has returned to 1980s levels, but the number of other STEM degrees has not increased (Natl. Science 2-44). Employers have made up for labor shortages by hiring skilled foreign workers, but other growing economies are competing with the US for these workers (Commission).

It should be noted that some question the feasibility and advisability of adopting other countries' educational practices.

Notwithstanding the significance of international assessment in most policy makers' minds, it should be noted that some question the validity of comparisons based on international assessments as well as the feasibility and advisability of adopting the educational practices of other countries (Cavanaugh and Manzo; Rothstein).

Kentucky's Competitive Disadvantages

Kentucky lags behind other states with respect to STEM employment, workforce education, patents issued, industry investment in research and development, fast-growing companies, K-12 mathematics achievement, Advanced Placement (AP) courses taken, and college degrees.

According to a 2007 report by the Council on Postsecondary Education's STEM task force, Kentucky is facing a number of competitive disadvantages. The report based its conclusions on a 3-month process in which the 110-member task force reviewed data, heard testimony, and examined a variety of national reports. Kentucky ranks among the bottom third of states with respect to STEM employment, workforce education, patents issued, industry investment in research and development, and fast-growing companies. Kentucky students lag behind the nation in

K-12 mathematics achievement, Advanced Placement courses taken, and college degrees earned (Commonwealth. Council).

Study Description

The Office of Education Accountability (OEA), at the direction of the Education Assessment and Accountability Review Subcommittee, undertook a three-part study of mathematics.

Among all of the STEM disciplines, mathematics is particularly important as a gateway skill for success in other disciplines (Kentucky Center). For this reason, the Office of Education Accountability (OEA), at the direction of the Education Assessment and Accountability Review Subcommittee, undertook this three-part study of mathematics in Kentucky.

Part 1 of the OEA study examines mathematics assessment and course-taking patterns. Part 2 focuses on teacher quality. Part 3 explores improvement efforts.

Part 1 of this study examines mathematics assessment and course-taking patterns. Part 2 focuses on teacher quality. Part 3 explores schools' and districts' improvement efforts.

The study report does not make recommendations regarding assessments because Kentucky is already working with other states, the National Governors Association, and the Council of Chief State School Officers to develop common standards, which will result in substantial changes to Kentucky's assessment and accountability system.

Organization of This Report

The remainder of Chapter 1 summarizes recent legislation relating to mathematics. Chapter 2 discusses assessments. Chapter 3 explores course-taking patterns and graduation requirements.

The remainder of Chapter 1 briefly summarizes recent legislation relating to mathematics. Chapter 2 analyzes students' mathematics skills, knowledge, and college readiness as measured by major assessments. Chapter 3 explores course-taking patterns in Kentucky compared to the US, state high school graduation requirements, and the relationship between course taking and achievement. The appendices include a list of statutes and regulations that relate to math, details about assessments, and other supporting information.

Throughout this report, references are made to fiscal years, which coincide with school years in Kentucky. Assessment results for the nation as a whole include public schools only.

Recent Kentucky Legislation Related to Mathematics

2005 House Bill 93

In 2005, House Bill 93 established the Math Achievement Fund, the Kentucky Center for Mathematics, and the Committee for Mathematics Achievement. It also modified the Teachers' Professional Growth Fund.

House Bill 93, passed by the General Assembly in 2005, established three programs aimed at enhancing Kentucky's mathematics outcomes: the Mathematics Achievement Fund, the Kentucky Center for Mathematics (KCM), and the Committee for Mathematics Achievement. The bill also modified the Teachers' Professional Growth Fund, which had been established in 2000.

2006 Senate Bill 130

In 2006, Senate Bill 130 required that all students take college-readiness tests and receive intervention if they do not meet established goals.

Senate Bill 130 requires that all students take part in the Educational Planning and Assessment System (EPAS), a trio of norm-referenced college-readiness tests consisting of EXPLORE for 8^{th} graders, PLAN for 10^{th} graders, and the ACT for 11^{th} graders. Senate Bill 130 requires districts to provide intervention for those students not meeting established goals.

2006 House Bill 197

In 2006, House Bill 197 funded pilots for end-of-course examinations.

House Bill 197 established a pilot program to develop end-of-course examinations for Algebra I, Algebra II, and Geometry.

2009 Senate Bill 1

In 2009, Senate Bill 1 mandated far-reaching changes to Kentucky's assessment and accountability system, starting with revised content standards.

Senate Bill 1 is a far-reaching mandate to reexamine the Commonwealth's assessment and accountability system, including the content to be tested, the types of tests to be administered, the timing of tests, and the basis for public school accountability. All provisions of the bill must be completed by December 2010. The bill directs KDE, in collaboration with the Council on Postsecondary Education (CPE), to plan and implement a comprehensive process for revising Kentucky's academic content standards. KDE and CPE are directed to work with the Education Professional Standards Board and other partners as appropriate and to seek advice from the School Curriculum, Assessment, and Accountability Council; the Office of Education Accountability; the Education Assessment and Accountability Review Subcommittee; and the National Technical Advisory Panel on Assessment and Accountability.

The revised content standards must

- focus on critical knowledge, skills, and capacities needed for success in the global economy;

- result in fewer but more in-depth standards to facilitate mastery learning;
- communicate expectations more clearly and concisely to teachers, parents, students, and citizens;
- be based on evidence-based research;
- consider international benchmarks; and
- ensure that the standards are aligned from elementary to high school to postsecondary education so that students can be successful at each educational level.

Review of postsecondary standards will occur simultaneously to ensure their alignment with the requirements set for secondary education outcomes (Commonwealth. Dept. of Ed. *Comprehensive*).

Statutes and Regulations Relating to Mathematics

Many Kentucky statutes and regulations relate to mathematics. These are listed in Appendix A and will be discussed in this report at points where they are relevant.

At the federal level, the No Child Left Behind (NCLB) Act requires all Title 1 schools to participate in annual testing of mathematics in grades 3-8 and one high school grade.[1] All states are required to participate in the biennial National Assessment of Educational Progress (US PL 107-110).

Data Needs for Evaluating Initiatives

Accurate, timely, and consistent data are crucial for research and evaluation. Better data collection and reporting are needed across all three education entities: the Council on Postsecondary Education (CPE), the Education Professional Standards Board (EPSB), and the Kentucky Department of Education (KDE).

Accurate, timely, and consistent data are crucial for research and evaluation. Because state-specific research and evaluation depend heavily on data collected and maintained by agencies, these agencies must provide appropriate oversight and governance of data collection and reporting. Several analyses and reviews that would be useful to inform policy were not possible due to inaccurate, incomplete, or inaccessible data. There is an overarching need for better data collection and reporting across all three education entities: EPSB, CPE, and KDE. This is especially critical in light of 2009 SB 1 requirements for a longitudinal data system and the cross-agency initiative to create a P-20 database that will link student data from preschool through advanced

[1] Because Kentucky had already been testing grades 5, 8, and 11 when NCLB went into effect, grade 11 was chosen as the high school grade for NCLB accountability.

university education. The value and integrity of each of the data systems maintained independently by the three educational agencies is critical to the success of the joint P-20 data initiative. Failure to provide adequate oversight and governance of data collection and reporting has resulted in unreliable and inaccurate data that are of limited value.

In the past 3 years, OEA has conducted a number of studies that relied on timely, accurate, and consistent data. Data that are frequently used and reported by KDE are audited for accuracy, but other data have not been audited or reviewed. As a result, there is inconsistency in the accuracy of data that OEA encounters through its research.

In a study of efficiency and effectiveness, OEA made the following recommendation:

> ….OEA also recommends that KDE consider improvements to its current data integrity efforts, including stricter enforcement of accounting protocols and monitoring of district compliance (Commonwealth. Legislative. Office. *Indicators* 82).

While KDE has made recent improvement efforts in some areas, there have not yet been comprehensive efforts across all data collections.

While KDE has made recent improvement efforts in some areas, there have not been comprehensive efforts to ensure accuracy across all data collections. This was apparent throughout OEA's study of mathematics. For example, OEA staff review of course-taking data determined that districts were not consistently assigning the correct course codes from the statewide valid course code list provided by KDE. In turn, KDE had made no efforts to enforce the proper use of the codes. KDE attempted to assist OEA in reaching out to districts to correct the course code data, but few districts chose to take part. The data remained inconsistent, and therefore are of limited use for compliance monitoring and research purposes.

If agencies have the authority to collect data, mandate reporting, and provide guidelines on data format and collection methods, then there must also be in place a means to monitor and audit the data, as well as repercussions for noncompliance. If certain data cannot be standardized or mandated in a certain form or format, then such data should be accompanied by clear caveats that inform users of the data limitations.

Recommendation 1.1

Recommendation 1.1 is that the CPE, EPSB, and KDE should have in place adequate methods of review and audit to ensure that their data contribute to a comprehensive, robust, and valuable P-20 database.

The Council on Postsecondary Education, the Education Professional Standards Board, and the Kentucky Department of Education should have in place adequate methods of review and audit to ensure that the data they collect and maintain contribute to a comprehensive P-20 database for use by the public and researchers.

Chapter 2

Students' Mathematics Knowledge and Skills

Kentucky's assessment and accountability system is undergoing profound changes. However, the results of past assessments will continue to constitute a record of progress.

This chapter compares Kentucky students' mathematics knowledge and skills to students nationally and over time. Kentucky's assessment and accountability system has undergone recent changes and will change significantly with the implementation of Senate Bill 1 in fiscal year 2011-2012. However, the results of past assessments will continue to constitute a record of state progress.

Different Content Standards Underlie Different Assessments

Underlying content standards that guide instruction, curricula, and assessments are assumptions about the knowledge and skills needed for college, careers, and other activities of everyday life. Every assessment has its own blueprint specifying how many test items will address each category of content standards. Performance standards specify the cut-off scores for proficient and other performance levels.

NCLB requires states to have content standards that guide and align instruction, curricula, and assessments (US PL 107-110; US. Dept. of Ed. *No Child*). Underlying those standards are assumptions—whether explicit or implicit—regarding the knowledge and skills needed for postsecondary education, the workplace, and everyday life. For each assessment of the standards, a blueprint specifies the content to be assessed and how many test items are devoted to each category of content standards. Performance standards specify the cut-off scores for students to reach the performance thresholds of distinguished, proficient, novice, and apprentice in Kentucky.

Kentucky is currently revising standards, alone and in concert with other states, through the Common Core State Standards Initiative.

Senate Bill 1 has been a catalyst for redesigning Kentucky standards in all subjects. Kentucky, along with 49 other states, joined the Common Core State Standards Initiative. This initiative is a collaborative effort by the National Governors Association and the Council of Chief State School Officers (CCSSO), in partnership with Achieve, Inc.; ACT, Inc.; the College Board; and 51 states and territories to develop a common core of internationally benchmarked mathematics and language arts standards (Natl. Governors. *Benchmarking*). College- and career-ready standards have been released and publicly reviewed. After those were refined and approved, the grade-by-grade standards were developed and released for public comment in the fall of 2009. Based on the terms of the contract, each state agrees to actively participate in the process. Upon completion, each state will consider adoption of the standards. Currently, the national collaborative is working only on mathematics and reading/language arts. Kentucky will also work on all other content areas as directed by SB 1 (Natl. Governors. Common).

The National Mathematics Advisory Panel recommended that math standards be streamlined to focus on the most important topics and defined proficiency as understanding key concepts; achieving automaticity and fluency with certain operations and facts; being able to execute standard algorithms flexibly, accurately, and automatically; and using these competencies to solve problems.

In addition to the CCSSO initiative, the National Mathematics Advisory Panel recommended that mathematics standards be streamlined to focus on the most important topics, especially the critical foundations of algebra: whole numbers, fractions, and particular aspects of geometry and measurement. Proficiency was defined as understanding key concepts; being able to perform certain operations and recall certain facts easily, accurately, and automatically; being able to execute standard algorithms flexibly, accurately, and automatically; and using these competencies to solve problems (Natl. Mathematics xvii).

Major Mathematics Assessments in Kentucky

Kentucky students' mathematics knowledge and skills are currently monitored with an array of achievement tests and college-readiness tests.

Kentucky students' mathematics knowledge and skills are currently monitored with a variety of achievement tests and college-readiness tests. Achievement tests determine the degree to which students have accomplished the broad array of learning goals. College-readiness exams were originally designed to gauge, in combination with high school grades and other information, a student's chances for success in college. An increasing number of states are incorporating college-readiness tests into their accountability systems as an indicator of how well the K-12 education system is preparing students for postsecondary education.

Tests may be norm referenced or criterion referenced and may be nationally standardized or customized to a particular state's content standards.

Tests may be either norm referenced (comparing a student's performance to a distribution of other students' scores), criterion referenced (comparing a student's performance to specific standards and goals), or both. They may be nationally standardized or customized to a particular state and its unique content standards.

All tests have limitations that should be taken into account when reviewing test results.

While testing is indispensable to accountability, all tests have limitations that should be taken into account when reviewing test results. Even the most rigorously designed and administered tests are estimates rather than exact measures of a student's knowledge and skills. For example, a test is a sample of a student's abilities on a specific day. But a student's performance varies from day to day, depending on such factors as motivation, health, and distractions. Questions on any given test are only a sample of the entire domain of knowledge and skills that could be tested. The constraints of a test environment make it impossible to adequately assess certain skills, such as the design and execution of complex projects (Way; Natl. Research).

The National Assessment of Educational Progress (NAEP) biennially assesses math in grades 4 and 8 at the state level and in grade 12 at the national level. NAEP is both criterion referenced and norm referenced.

Table 2.1 provides brief descriptions of the major mathematics assessments administered in Kentucky. The US Department of Education administers the National Assessment of Educational Progress (NAEP) biennially to samples of 4th and 8th graders in Kentucky and all other states. In addition, 12th graders are tested at the national level only. NAEP is both criterion referenced and norm referenced.

The Kentucky Core Content Test (KCCT) began testing in grades 5, 8, and 11 in FY 1999; grades 3, 4, 6, and 7 were added in FY 2007. KCCT is criterion-referenced and tailored to Kentucky's standards.

The Kentucky Core Content Test (KCCT) began annual statewide testing in grades 5, 8, and 11 in FY 1999. Tests in grades 3, 4, 6, and 7 were added in FY 2007 in order to comply with NCLB. KCCT is a criterion-referenced test that is tailored to Kentucky's core content standards.

The college readiness of students in Kentucky and some other states is assessed annually with EXPLORE, PLAN, and the ACT. These exams are criterion referenced and, to some extent, norm referenced. However, EXPLORE and PLAN norms have not been updated since 2005, and there are no norms for states that require all students to take the ACT, as does Kentucky.

The college readiness of students in Kentucky is assessed annually with EXPLORE, PLAN, and the ACT, which comprise the Educational Planning and Assessment System (EPAS). Since FY 2007, modified versions of the ACT called PLAN and EXPLORE have been administered for diagnostic purposes to all of Kentucky's 10th graders and 8th graders, respectively. In FY 2008, all Kentucky 11th graders began taking the ACT. The EPAS exams, which are developed and scored by ACT, Inc., are criterion referenced and, to some extent, norm referenced. In 2005, ACT, Inc. administered EXPLORE and PLAN to samples of students in order to set national norms; these norms are not updated annually. Currently, there are no national norms for 11th graders taking the ACT because Kentucky is one of only five states that administer the ACT to all students (Achieve. *Closing* 15).[1] The ACT is taken voluntarily by students in other states with a broad range of participation rates; therefore, results are skewed by self-selection.

AP exams are administered annually to students who choose to participate. Two levels of calculus, two levels of computer science, and statistics make up the math exam choices.

Designed and overseen by the College Board, Advanced Placement (AP) exams are administered annually in May to students who choose to participate. Two levels of calculus, two levels of computer science, and statistics make up the mathematics exam choices.

[1] Colorado, Illinois, Kentucky, Michigan, and Tennessee administer the ACT to all students as part of their statewide assessments.

Table 2.1
Major Mathematics Assessments Conducted in Kentucky as of Fiscal Year 2010

Assessment Characteristics	Type of Mathematics Assessment					
	National Assessment of Educational Progress	Kentucky Core Content Test	Educational Planning and Assessment System			Advanced Placement
			EXPLORE	PLAN	ACT	
Frequency	Biennial since 2003	Annual	Annual	Annual	Annual	Annual
Test Administration Window	Late Jan. through early March	Late April/ early May	Sept.	Sept.	March	May
Smallest Unit for Which Results Are Reported	State (and Jefferson County as part of the 2009 urban district report)	School (student receives an overall score, no subdomains)	Student	Student	Student	Student
Students Tested	Randomly selected representative samples of 4th and 8th graders	All students in grades 3-8 and grade 11	All 8th graders as of FY 2007	All 10th graders as of FY 2007	All 11th graders as of FY 2008	Self-selected
Oversight	US Dept. of Education	Kentucky Department of Education	ACT, Inc.	ACT, Inc.	ACT, Inc.	College Board

Notes: In 2007, randomly selected representative samples of 3,400 4th graders and 2,700 8th graders participated in Kentucky's National Assessment of Educational Progress mathematics assessment. In spring 2009, Kentucky high schools had the option of administering the Kentucky Core Content Test in late April so as not to conflict with Advanced Placement (AP) exams in May. In 2008, a total of 3,877 AP mathematics exams were taken. A subdomain is a category within a subject; subdomains within the KCCT mathematics test are Number Properties and Operations; Measurement; Geometry; Data Analysis and Probability; and Algebraic Thinking.
Sources: Staff compilation of information from ACT. "EPAS"; College Board. About AP; Commonwealth. Dept. of Ed. *2006-2007 Technical Report*; US. Dept. of Ed. Inst. Natl. NAEP Overview.

Different assessments often yield different results because every assessment reflects a unique set of standards regarding what students should know and be able to do.

Different assessments often yield different results because every assessment reflects a unique set of standards. Underlying these standards are different perspectives regarding what graduates should know and be able to do by the time they enter college or work. In addition, there is considerable variation in the proportion of test items devoted to each topic, the design of test items, scoring methods, and definitions of proficient and other performance standards. Appendices B, C, and D provide additional background information on major assessments that are conducted in Kentucky.

Overview of Kentucky Students' Performance in Math

On almost all measures that have national norms, Kentucky scores significantly below the national norms.

Table 2.2 provides an overview of the results for the major mathematics assessments conducted in Kentucky. On almost all measures that have national norms, Kentucky scores significantly below the nation.

Table 2.2
Overview of Mathematics Performance in Kentucky and US
Most Recent Year of Each Assessment

Mathematics Performance Measure	**KY**	**US**
National Assessment of Educational Progress (NAEP), Winter/Spring 2007		
Grade 4 – Average Score on 0-500 Scale	235*	239
– Proficient/Advanced	31%*	39%
Grade 8 – Average Score on 0-500 Scale	279	280
– Proficient/Advanced	27%*	32%
Kentucky Core Content Test (KCCT), Spring 2008		
Grade 3 – Proficient/Distinguished	74%	NA
Grade 4 – Proficient/Distinguished	71%	NA
Grade 5 – Proficient/Distinguished	64%	NA
Grade 6 – Proficient/Distinguished	63%	NA
Grade 7 – Proficient/Distinguished	57%	NA
Grade 8 – Proficient/Distinguished	51%	NA
Grade 11 – Proficient/Distinguished	38%	NA
EXPLORE, Grade 8, Fall 2008		
Average Score on 0-25 Scale	14.6	15.1
Meet/Exceed Readiness Benchmark Score of 17	29%*	36%
PLAN, Grade 10, Fall 2008		
Average Score on 0-32 Scale	16.4	17.4
Meet/Exceed Readiness Benchmark Score of 19	22%*	34%
ACT, Grade 11, Spring 2009		
Average Score on 0-36 Scale	18.2	NA
Meet/Exceed General College Mathematics Readiness Benchmark Score of 18	44%	NA
Meet/Exceed College Algebra Readiness Benchmark Score of 22	21%	NA
Meet/Exceed College Calculus Readiness Benchmark Score of 27	6%	NA
Advanced Placement, Spring 2008		
Percent of Graduating Class That Took at Least One Mathematics AP Exam During High School	6.6%*	9.3%

Notes: * indicates that the difference between Kentucky and the US is statistically significant ($p < .05$). For NAEP, the US column shows nationally representative results for public school students. For EXPLORE and PLAN, the US column for all years shows nationally representative results from a study conducted in fall 2005. EXPLORE and PLAN readiness benchmarks indicate the scores at which examinees have a 50 percent chance of later achieving the college algebra readiness benchmark on the ACT. Readiness benchmarks for the ACT correspond to a 50 percent chance of earning a B grade and about a 75 percent chance of earning a C grade in each indicated college course. ACT, Inc. provided the ACT benchmark for college algebra, and the Kentucky Council on Postsecondary Education provided the ACT benchmarks for general college mathematics and calculus.
Sources: Staff compilation of data from ACT. *ACT State Test* 7-10, *EXPLORE Profile for* FY 2009 2, *PLAN Profile for FY* 2009 2, and *What Are*; College Board. *The 5th Annual*; Commonwealth. Dept. *Kentucky Performance Report* for FY 2008 31-33, 99-101, 155; US. Dept. of Ed. Inst. Natl. *The Nation's* 16, 32.

The National Assessment of Educational Progress

NAEP is the only nationally representative achievement test. Although it is not without limitations, NAEP is widely respected.

The US Department of Education developed NAEP to provide a national picture of student achievement. Today, NAEP remains the only nationally representative assessment of student achievement. Although it is not without limitations, NAEP is widely respected for the quality of its design, its history as a national indicator, and the rigor of its standards (Barth; Standard & Poor's).

NAEP assessments have been conducted at the national level since 1969. State-level NAEP tests began in the early 1990s, but it was not mandatory for all states to participate until 2003 (US. Dept. of Ed. Inst. Natl. About; PL 107–110 Sec. 1501(a)(1)-(3)).

Because NAEP results are based on samples of students, statistical tests are required to determine whether differences are likely real or simply due to random sampling error. Results are reported for the nation and each state, but not for individual school districts, schools, or students.

The state-level NAEP assesses representative samples of 4th graders and 8th graders. The most recent mathematics assessment was in 2009, but data were not available at the time of this report; they are expected to be released on October 14, 2009. The most recent mathematics assessment for which data were released was conducted in 2007. That assessment tested a total of 196,100 4th graders, including 3,400 in Kentucky, and 154,300 8th graders, including 2,700 in Kentucky. Because NAEP results are based on samples of students, statistical tests are required to determine whether differences are likely real or simply due to random sampling error. Results are reported for the nation and each state but not for individual school districts, schools, or students.

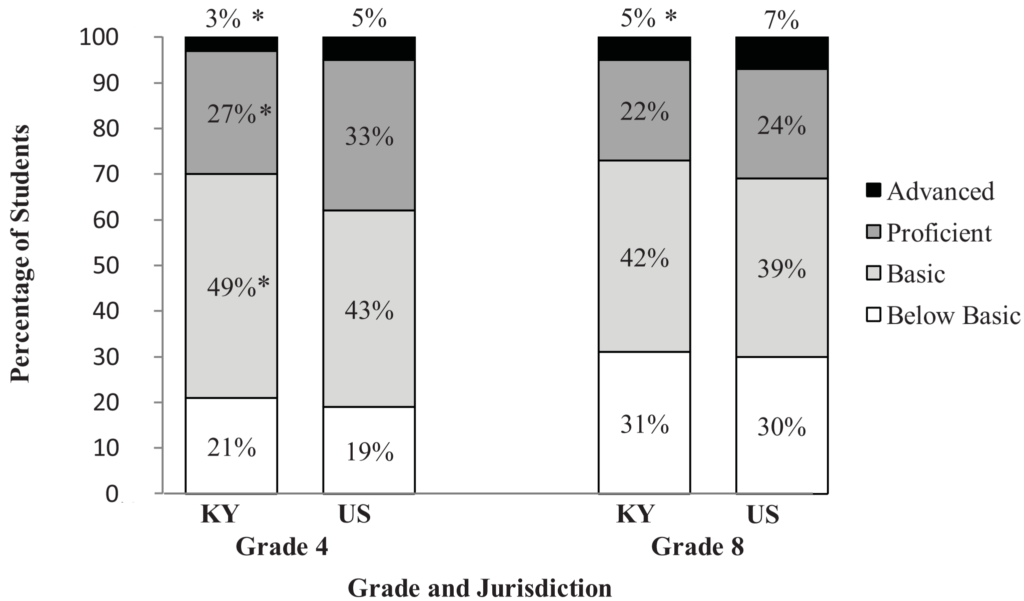
NAEP results are reported as average scores and as the percentages of students at each of four achievement levels.

NAEP results are reported as average scores and as the percentages of students at each of four achievement levels. The highest level is advanced, denoting superior performance. The proficient level represents "solid academic performance" and competency with challenging subject matter. The basic level represents "partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at a given grade." A below basic level is reported but not defined (US. Dept. of Ed. Inst. Natl. The NAEP). Appendix C contains detailed definitions of the achievement levels.

Compared to the nation, significantly smaller percentages of Kentucky's 4th graders were considered proficient or advanced. Kentucky's 8th graders were on par with the nation, except for having a small but significant difference in the percentage considered advanced.

Figure 2.A shows NAEP mathematics assessment results for Kentucky and the nation as a whole for 2007, the most recent year for which results have been reported. Compared to the nation, significantly smaller percentages of Kentucky's 4th graders were considered proficient or advanced. Kentucky's 8th graders were on par with the nation, except for having a small but significant difference in the percentage considered advanced.

Figure 2.A
NAEP Mathematics Results: Kentucky and the US, Grades 4 and 8, 2007



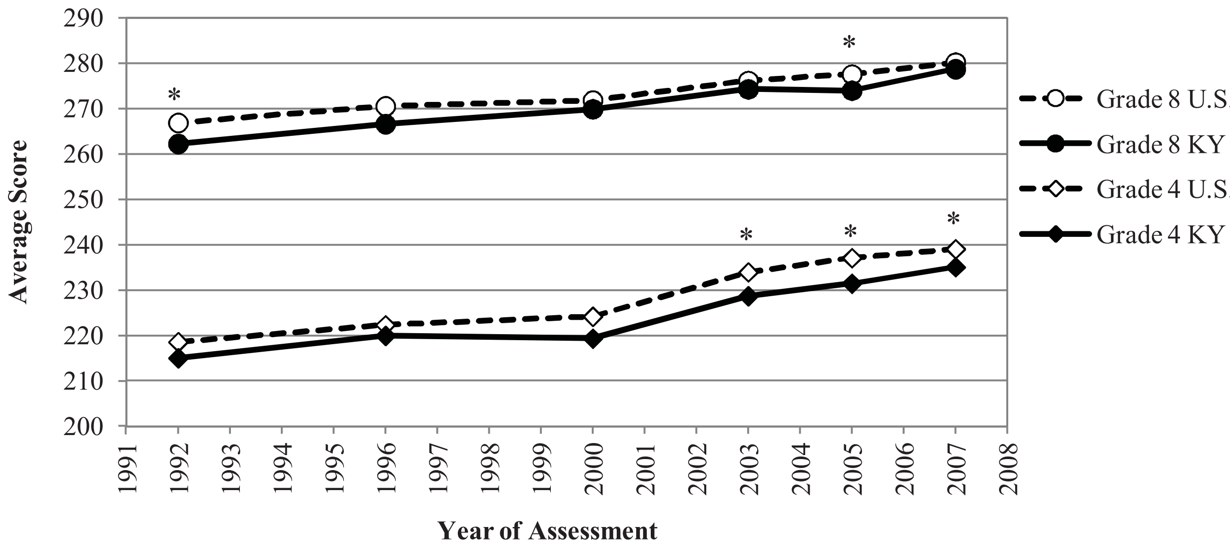
Notes: * indicates statistically significant differences between Kentucky and the US ($p < .05$). Scores are on a 0-500 scale. For grade 4, below basic indicates scores below 214, basic is 214-248, proficient is 249-281, and advanced is 282 or higher. For grade 8, below basic indicates scores below 262, basic is 262-298, proficient is 299-332, and advanced is 333 or higher.
Source: US. Dept. of Ed. Inst. Natl. *The Nation's*.

NAEP Trends

Scores have risen in both grades since NAEP testing began in the early 1990s. Kentucky's 4th graders started on par with the nation but were significantly lower in the three most recent assessments reported at the time of this report. Kentucky's 8th graders have been on par with the nation in all years except 1992 and 2005.

As Figure 2.B shows, trends in Kentucky's average mathematics scores mirror those of the nation. Scores have risen in both grades since NAEP testing began in the early 1990s. Kentucky's 4th graders started on par with the national average but were significantly lower in the three most recently reported assessments. Kentucky's 8th graders have been on par with the nation in all years except 1992 and 2005.

Figure 2.B
Trends in Average NAEP Mathematics Scores, 1992 to 2007

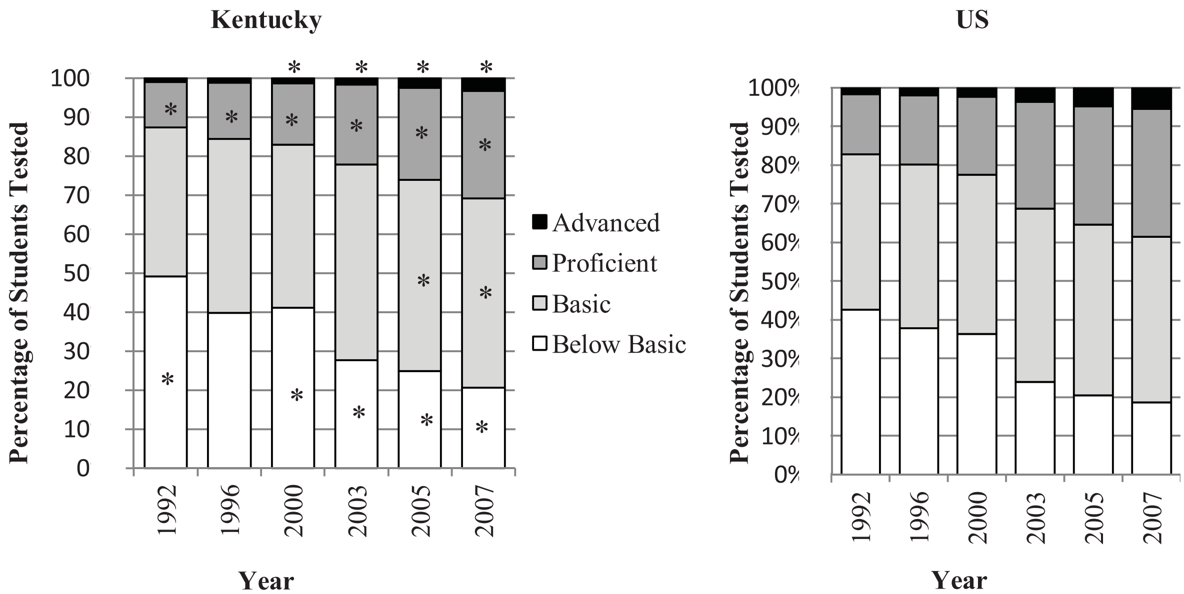


Notes: * In 1992 and 2005, Kentucky 8th graders scored significantly lower than the US public school average ($p < .05$). In 2003, 2005, and 2007, Kentucky 4th graders scored significantly below the US average. Fourth graders were not tested in 1990. Participation in NAEP by all states was not mandatory until 2003. Accommodations—special test conditions for students with disabilities and for English language learners—were not permitted in 1990, 1992, and 1996 results shown.
Source: Staff analysis of data from US. Dept. of Ed. Inst. Natl. *NAEP Data*.

Since NAEP began, achievement has improved at all levels of ability in Kentucky and the nation. There have been steady declines in the percentages of students scoring below basic and steady increases in percentages of students scoring at or above proficient.

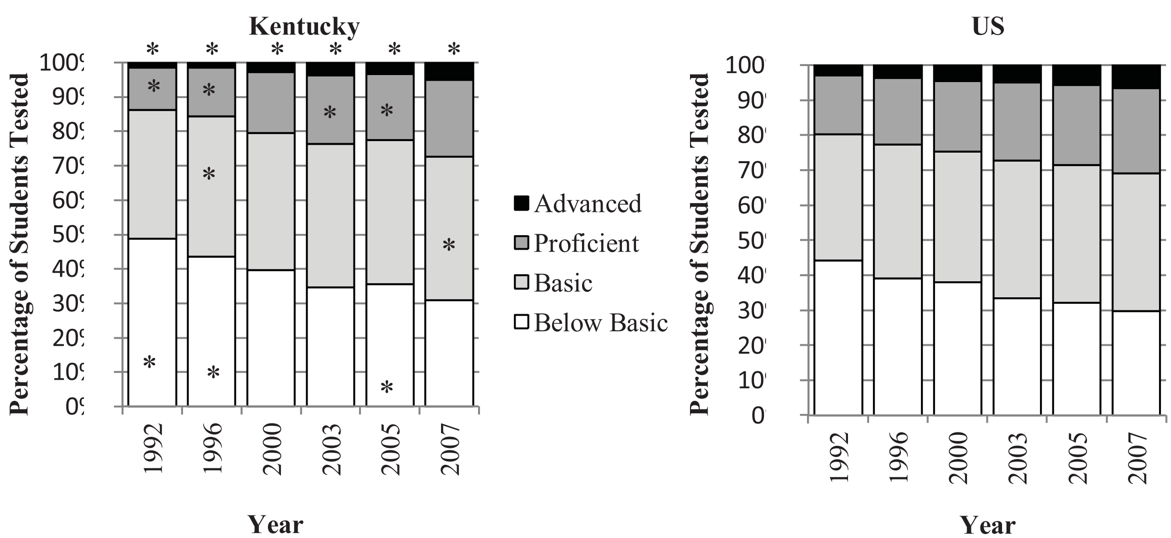
Since NAEP began, achievement has improved at all levels of ability in Kentucky and the nation. As Figures 2.C and 2.D show, there have been steady declines in the percentages of students scoring below basic and steady increases in percentages of students scoring at or above proficient.

Figure 2.C
Trends in Achievement Levels, Grade 4 NAEP Mathematics, 1992-2007



Notes: * indicates statistically significant differences between Kentucky and the US. Participation in NAEP by all states became mandatory in 2003. Accommodations—special test conditions for students with disabilities and for English language learners—were not permitted in 1992 and 1996 results shown.
Source: Prepared by staff using data from US. Dept. of Ed. Inst. Natl. *NAEP Data*.

Figure 2.D
Trends in Achievement Levels, Grade 8 NAEP Mathematics, 1992-2007

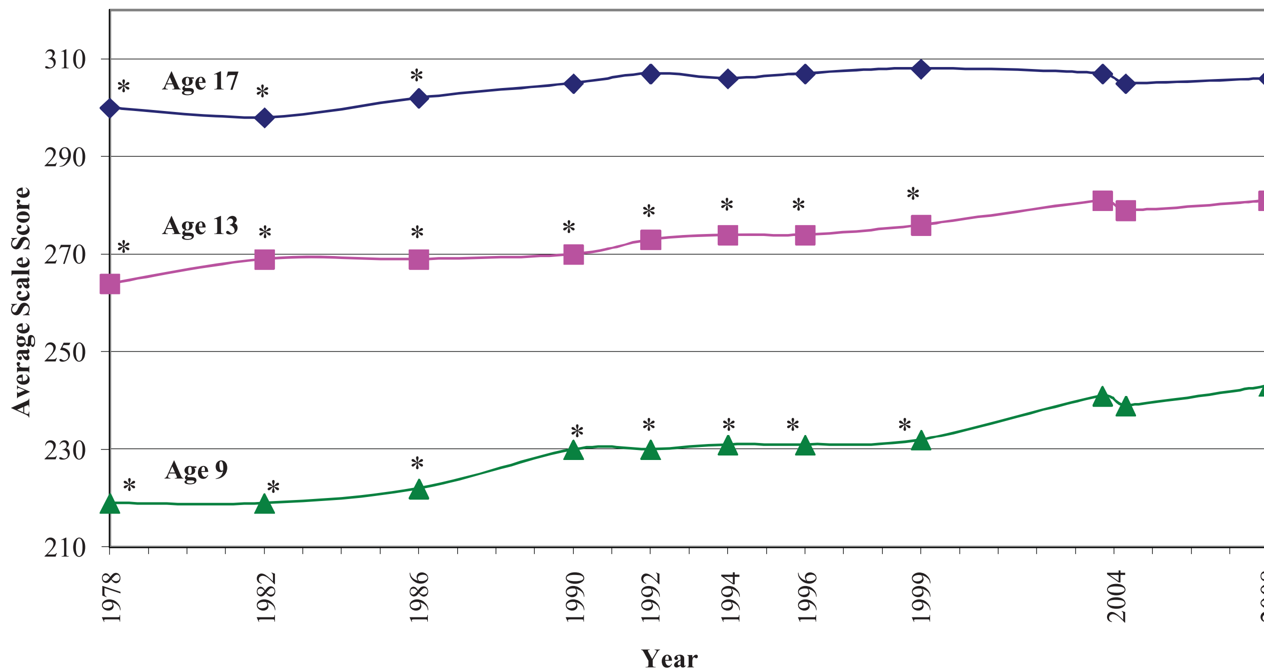


Notes: * indicates statistically significant differences between Kentucky and the US. Participation in NAEP by all states became mandatory in 2003. Accommodations—special test conditions for students with disabilities and for English language learners—were not permitted in 1992 and 1996 results shown.
Source: Prepared by staff using data from US. Dept. of Ed. Inst. Natl. *NAEP Data*.

Although 12th graders are not assessed at the state level, they are at the national level. The NAEP long-term trend assessment shows that math performance of 17-year-olds has changed little since 1990, while 13-year-old and 9-year-old performance improved significantly through 2004.

Although 12th graders are not assessed at the state level, they are at the national level. The NAEP long-term trend assessment is administered according to student age instead of grade. The three lines in Figure 2.E represent the performance of 17-year-olds, 13-year-olds, and 9-year-olds. As the figure shows, performance of the nation's 17-year-olds has changed little since 1990, while 13-year-old and 9-year-old performance continued to improve through 2004. The slight increases in scores between 2004 and 2008 are not statistically significant.

Figure 2.E
NAEP Long-Term Trend Assessment in Mathematics by Age of Students
United States, 1978 to 2008



Notes: * indicates a score that was significantly different from the 2008 score. In 2004, the assessment format was revised. Half of the 2004 sample was randomly selected to take the original assessment, while the other half took the revised assessment. In the figure, the results of the 2004 original assessment are represented by the symbol on the left, and the results of the 2004 revised assessment are represented by the symbol on the right. In 2008, all students were administered the revised format.
Source: US. Dept. of Ed. Inst. Natl. *NAEP Data.*

State Comparisons

Kentucky's NAEP performance ranks among the lower half of states.

Kentucky's NAEP performance ranks among the lower half of states. As Table 2.3 shows, in the 2007 assessment of 4th graders, 29 states had average scores that were significantly higher than Kentucky's, 13 scored about the same, and 7 states and the District of Columbia scored significantly lower. As Table 2.4 shows, on the assessment of 8th graders, 28 states had significantly higher scores, 9 scored about the same, and 13 states and the District of Columbia scored significantly lower.

Table 2.3
NAEP 4th-Grade Mathematics Results by State, 2007

State	Grade 4 Average Score	Statistical Significance Compared to Kentucky
Massachusetts	252	>
New Hampshire	249	>
New Jersey	249	>
Kansas	248	>
Minnesota	247	>
Vermont	246	>
Indiana	245	>
North Dakota	245	>
Ohio	245	>
Montana	244	>
Pennsylvania	244	>
Virginia	244	>
Wisconsin	244	>
Wyoming	244	>
Connecticut	243	>
Iowa	243	>
New York	243	>
Washington	243	>
Maine	242	>
Texas	242	>
Delaware	242	>
Florida	242	>
North Carolina	242	>
Idaho	241	>
South Dakota	241	>
Maryland	240	>

State	Grade 4 Average Score	Statistical Significance Compared to Kentucky
Colorado	240	>
Missouri	239	>
Utah	239	>
US	**239**	**>**
Arkansas	238	=
Michigan	238	=
Nebraska	238	=
Alaska	237	=
Illinois	237	=
Oklahoma	237	=
South Carolina	237	=
Oregon	236	=
Rhode Island	236	=
West Virginia	236	=
Georgia	235	=
Kentucky	**235**	**---**
Hawaii	234	=
Tennessee	233	=
Arizona	232	<
Nevada	232	<
California	230	<
Louisiana	230	<
Alabama	229	<
Mississippi	228	<
New Mexico	228	<
District of Columbia	214	<

Notes: > indicates states with significantly higher scores than Kentucky's, = indicates states with scores that are not significantly different from Kentucky's, and < indicates states with significantly lower scores than Kentucky's.
Source: US. Dept. of Ed. Inst. Natl. *NAEP Data*.

Table 2.4
NAEP 8th-Grade Mathematics Results by State, 2007

State	Grade 8 Average Score	Statistical Significance Compared to Kentucky
Massachusetts	298	>
Minnesota	292	>
North Dakota	292	>
Vermont	291	>
Kansas	290	>
New Jersey	289	>
South Dakota	288	>
Virginia	288	>
New Hampshire	288	>
Montana	287	>
Wyoming	287	>
Maine	286	>
Colorado	286	>
Pennsylvania	286	>
Texas	286	>
Maryland	286	>
Wisconsin	286	>
Iowa	285	>
Indiana	285	>
Washington	285	>
Ohio	285	>
North Carolina	284	>
Oregon	284	>
Nebraska	284	>
Idaho	284	>
Delaware	283	>
Alaska	283	>
Connecticut	282	=
South Carolina	282	=
Utah	281	=
Missouri	281	=
Illinois	280	=
US	**280**	**=**
New York	280	=
Kentucky	**279**	**---**
Florida	277	=
Michigan	277	=
Arizona	276	=
Rhode Island	275	<
Georgia	275	<
Oklahoma	275	<
Tennessee	274	<
Arkansas	274	<
Louisiana	272	<
Nevada	271	<
California	270	<
West Virginia	270	<
Hawaii	269	<
New Mexico	268	<
Alabama	266	<
Mississippi	265	<
District of Columbia	248	<

Notes: > indicates states with significantly higher scores than Kentucky's, + indicates states with scores that are not significantly different from Kentucky's, and < indicates states with significantly lower scores than Kentucky's.
Source: US. Dept. of Ed. Inst. Natl. *NAEP Data*.

Kentucky Core Content Test

KCCT results are reported at the school and district levels, with overall scores and scores for each of the subdomains within math. Students receive overall scores, but no scores for the subdomains of number properties and operations, measurement, geometry, data analysis, and probability. Grades 5, 8, and 11 have been tested since 1999. Grades 3, 4, 6, and 7 were added in FY 2007. Results are reported as four performance levels similar to NAEP's achievement levels, and as average scores.

The Kentucky Core Content Test has long been the heart of the Commonwealth Accountability Testing System. Results are reported at the school and district levels, with overall scores and scores by the subdomains of number properties and operations, measurement, geometry, data analysis, and probability. Students receive individual overall scores but no scores by subdomain. Mathematics results for grades 5, 8, and 11 have been reported since 1999. Since FY 2007, results have also been available for grades 3, 4, 6, and 7. Results are reported in terms of four performance levels similar to NAEP's achievement levels; however, KCCT results provide further detail by breaking out the novice and apprentice levels into three subgroups, as shown in Table 2.5.

Results are also reported in terms of average scores on an 80-point scale for each grade, and mathematics index values on a scale of 0 to 140. The index is a weighted average of the proportion of students scoring at each performance level; weights range from 0 for the lowest performance level to 140 for the highest, as shown in Table 2.5. For a simple example, suppose one-third of a school's students were at the apprentice high level and the other two-thirds were at the proficient level. The academic index would then be: 80 x .33 + 100 x .67 = 90.

Table 2.5
Weights for Mathematics Index

Performance Level	Weight
Novice non-performance	0
Novice medium	13
Novice high	26
Apprentice low	40
Apprentice medium	60
Apprentice high	80
Proficient	100
Distinguished	140

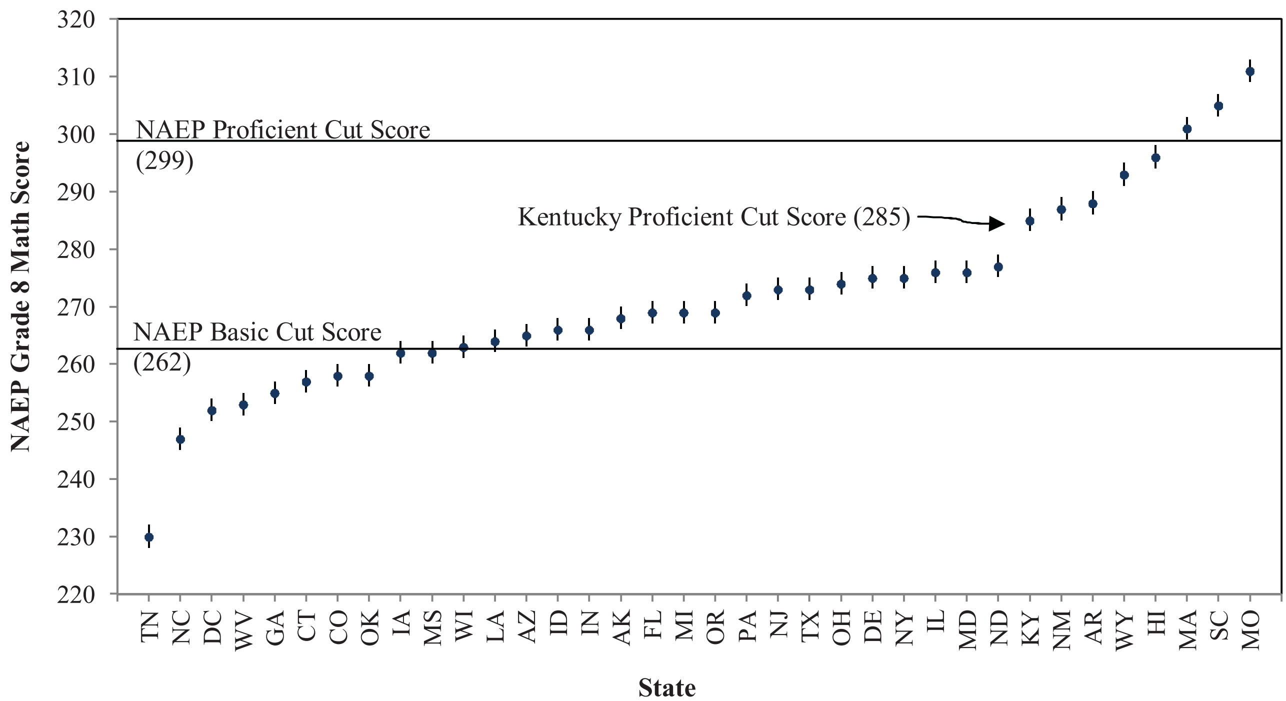
Note: The index is a weighted average of the proportion of students scoring at each performance level.
Source: Commonwealth. Dept. *CATS* 52.

KCCT Compared to NAEP

Because KCCT is modeled on NAEP, the two tests are similar, but not in all respects. KCCT, like most state-designed assessments, reports higher proficiency rates. Among 36 states analyzed, Kentucky had the 8th highest proficiency standard for grade 8 students.

Definition of Proficient and Other Performance Levels. Because development of KCCT used NAEP as a model, the two tests are similar, but not in all respects. KCCT, like most state-designed assessments, reports higher proficiency rates than NAEP.[2] Figure 2.F shows the results of an analysis that compared the 2005 NAEP mathematics assessment for 8th graders to 36 state assessments, including Kentucky's. Only three states appeared to define proficiency as rigorously as NAEP. While NAEP's "cut score" (minimum score) for proficiency is 299, cut scores set by states on their own tests were equivalent to only about 278, on average, and ranged as low as 247. Kentucky, with a proficiency cut score estimated at 285, is closer to NAEP's threshold than most other states (US. Dept. of Ed. Inst. Natl. *Mapping* 15).

Figure 2.F
Proficiency Cut Scores for State Tests Mapped Onto the NAEP Scale
Grade 8 Mathematics, 2005



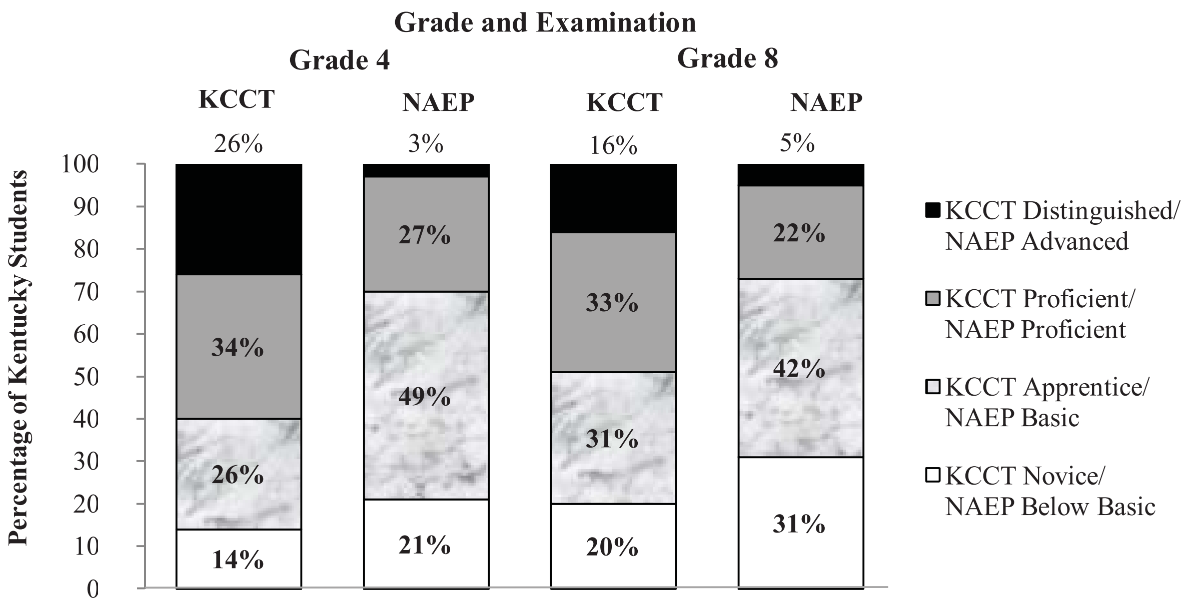
Note: For each state, a dot represents the NAEP equivalent and bars above and below it represent the margins of error, assuming 95 percent confidence. A cut score is the minimum score that defines a category; for example, NAEP considers a student proficient if the student's score is 299 or above.
Source: Staff graphic of data from US. Dept. of Ed. Inst. Natl. *Mapping* 11.

[2] Proficiency means scoring proficient or higher. A proficiency rate is the percentage of students who score proficient or higher.

In 2007, 4th-grade proficiency rates were 60 percent according to KCCT and 30 percent according to NAEP. The 8th-grade proficiency rates were 49 percent in KCCT and 27 percent in NAEP.

The analysis shown in Figure 2.F could not be conducted for 4th-grade mathematics because there was no 4th-grade KCCT for mathematics in 2005. However, some insights can be gained by comparing KCCT's novice, apprentice, proficient, and distinguished classifications to NAEP's achievement levels. As Figure 2.G shows, discrepancies at the 8th-grade level between KCCT and NAEP were not quite as great as the discrepancies at the 4th-grade level. In 2007, 4th-grade proficiency rates were 60 percent according to KCCT and 30 percent according to NAEP. The 8th-grade proficiency rates were 49 percent in KCCT and 27 percent in NAEP.

Figure 2.G
Comparison of KCCT Performance Levels and NAEP Achievement Levels for Kentucky Students, 2007



Sources: US. Dept. of Ed. Inst. Natl. *NAEP Data*; Commonwealth. Dept. of Ed. *Kentucky Performance*.

The discrepancies between state tests and NAEP were discussed in OEA's 2008 compendium of state rankings. The discrepancies, which vary greatly by state and appear to be growing over time, are due to such factors as differences in alignment with content standards, consequences for results, cut scores, content, format, administration procedures, scales, and inclusion rates of students with disabilities and English language learners.

The discrepancies between state tests and NAEP are discussed in the OEA report *Compendium of State Education Rankings 2008* (45-47). These discrepancies, which vary greatly by state and appear to be growing over time, are due to several factors:

- State tests better align with students' opportunities to learn because they are based on the unique content standards that drive instruction and curricula in that state.
- The high stakes of state tests may spur schools to better prepare and motivate students.
- Research suggests that NAEP's minimum cut score for proficiency is set too high.

- Many states may be setting the minimum cut score for proficiency too low.
- In addition, the tests differ in content, format, administration procedures (such as timing), scales, and inclusion rates of students with disabilities and English language learners.

Test Content and Emphasis. As Table 2.6 shows, the broad content areas (also called subdomains) of knowledge and skills tested in NAEP are very similar to those tested in KCCT; however, the tests use somewhat different definitions and have different formats, scales, and item types. Brief descriptions of each NAEP content area are provided below.

- The Numbers and Operations content area includes ways to represent, calculate, and estimate with numbers. These skills are used in everyday life for such activities as comparing prices, buying or leasing a car, balancing a checkbook, investing savings, and understanding much of what appears in the daily news. High school graduates need to fundamentally understand the relationships between numbers to add, subtract, multiply, and divide with and without a calculator. Familiarity with numbers is also needed to make reasonable estimations and mental computations.
- Measurement deals with such attributes as temperature, capacity, length, area, and volume.
- Geometry involves working with two- and three-dimensional shapes and understanding the logic of geometric proofs and theorems. In everyday life, graduates need to understand spatial relations to solve basic problems, such as resolving the best way to fit an oversized object through a door or deciding how to design a house for maximum living space with minimal timber costs.
- The Statistics and Probability content area comprises data representation, characteristics of data sets, experiments and samples, and probability. Employers and professors expect graduates to be able to make predictions and develop and evaluate inferences from data. Graduates must be able to interpret, analyze, and describe data quickly and accurately. They must be able to interpret charts, graphs, diagrams, and other visual representations of data, which are abundant in daily life.
- Algebra covers patterns, the use of variables, algebraic expressions, and functions. Colleges and employers expect high school graduates to understand algebra and apply their knowledge to everyday problems. For example, graduates should be able to predict savings based on a rate of interest, project business revenues, and estimate future populations

based on known population growth rates (Achieve. *The Expectations* 9; National. Assessment 9, 35-42).

Table 2.6
Knowledge and Skills Tested by NAEP and KCCT, 2007

NAEP Content Area	KCCT Subdomain	Percentages of Test Items: Grade 4 NAEP	Grade 4 KCCT	Grade 8 NAEP	Grade 8 KCCT
Numbers and Operations	Number Properties and Operations	40	40	20	22
Measurement	Measurement	20	10	15	15
Geometry	Geometry	15	20	20	20
Statistics and Probability	Data Analysis and Probability	10	15	15	15
Algebra	Algebraic Thinking	15	15	30	28

Sources: US. Dept. of Ed. Inst. Natl. *Mathematics*; Commonwealth. Dept. of Ed. Kentucky Core.

The noted discrepancies bring into question the state-developed cut points and definition of proficiency in absolute terms, but KCCT results are useful in relative terms; they offer more opportunities than NAEP to compare grades, years, and geographic levels.

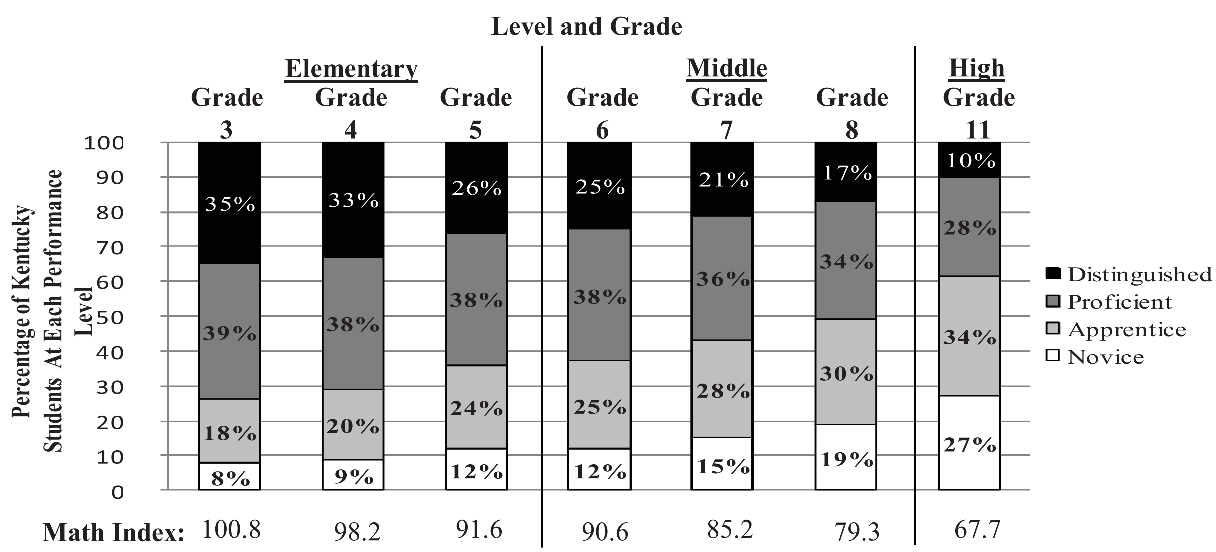
The discrepancies noted in Figures 2.F and 2.G bring into question the state-developed cut points and definition of proficiency in absolute terms, but KCCT results are useful in relative terms; they offer more opportunities than NAEP to compare grades, years, and geographic levels.

KCCT Results by Grade Level

In FY 2008, KCCT proficiency rates ranged from 74 percent in 3rd grade to 38 percent in 11th grade.

Figure 2.H shows KCCT performance levels and the mathematics index. Proficiency rates range from 74 percent in 3rd grade to 38 percent in 11th grade.

Figure 2.H
KCCT Mathematics Performance Levels by Grade, 2008

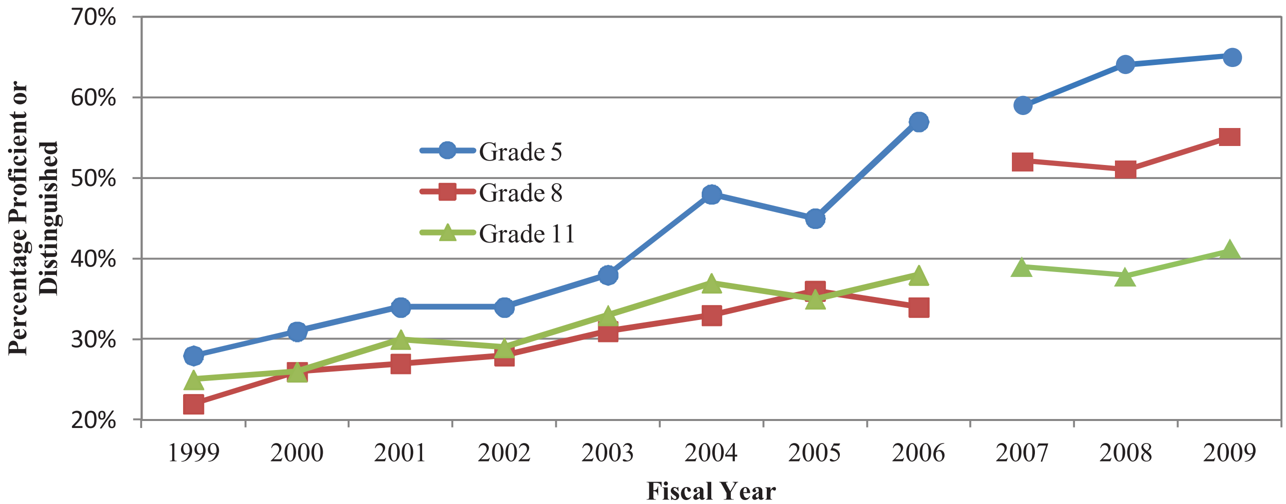


Source: Staff preparation of data from Commonwealth. Dept. of Ed. *Kentucky Performance* 2008.

Grade-level comparisons for a single year give the mistaken impression that a student's performance plummets throughout middle and high school. However, when examined by cohort, KCCT scores have been increasing over time.

Grade-level comparisons for a single year give the mistaken impression that a student's performance plummets throughout middle and high school. However, this is not true for most students. It is important to recognize that test results by grade for a single year reflect seven cohorts of students. As Figure 2.I illustrates, KCCT scores have been increasing over time, with each successive cohort of students starting at a higher point than the preceding cohort. It is also evident that improvement has been slower for 8th and 11th graders than for 5th graders.

Figure 2.I
Trends in KCCT Mathematics Proficiency Rates, By Grade
Fiscal Year 1999 to Fiscal Year 2008



Note: The discontinuity in the trend lines indicates that scores in 2007 and subsequent years are not comparable to scores in 2006 and preceding years. The proficiency rate is the total percentage of students who are proficient or distinguished.
Source: Staff analysis of data from Commonwealth. Dept. of Ed. *Kentucky Performance*.

Most assessment results start low and rise steadily over time. When changes are made to the assessment, scores drop immediately and then begin to rise again. There are varying opinions as to exactly what causes these cycles.

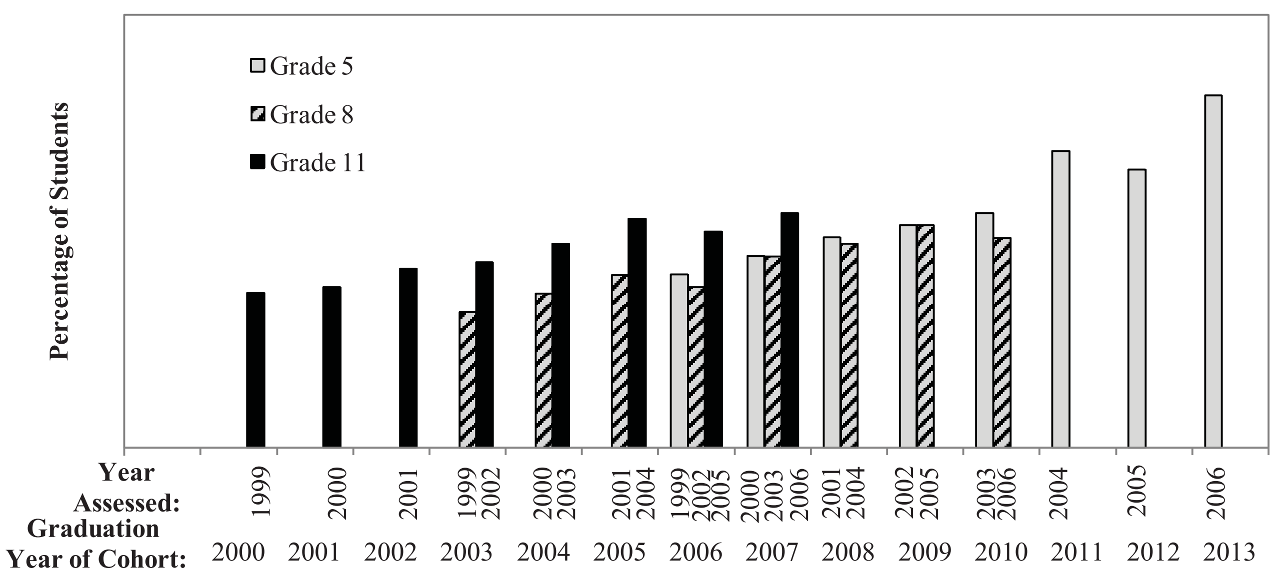
Experts have pointed out that most assessment results start low and rise steadily over time. When changes are made to the assessment, scores drop immediately and then begin to rise again (Linn. "Assessments").

There are varying opinions as to exactly what causes these cycles. They could reflect, in part, a gradual narrowing of teaching to focus on likely test questions; hence, ethical standards must be followed in order to avoid impacting scores without any genuine learning (Washington). However, the cycles may also represent some real gains in knowledge and skills. Assessments are meant to provide feedback that is used for improving instruction and curriculum; this is one aspect of the consequential validity of a test (Linn, Baker, and Dunbar).

Figure 2.J tracks proficiency rates by cohort. It is evident that each successive cohort almost always starts at a higher level than the preceding cohort, and that each cohort's proficiency rate at grade 11 is higher, not lower, than it was at grade 5.

Some cohorts in Figure 2.J appear to have had a middle school slump. In the national literature, educators and policy makers often refer to middle school slumps and high school stagnation, which are dips in performance after students transfer to the next grade level. Such dips in performance have been attributed to a variety of factors; however, no definitive studies have pinpointed the causes (Cook; Editorial. "Mathematics Stagnation"; Yecke). KCCT's trends mirror NAEP and international trends (US. Dept. of Ed. Inst. Natl. *NAEP Data*; LeTendre).

Figure 2.J
KCCT Mathematics Proficiency Rates for Fiscal Year 1999 through Fiscal Year 2006
Grouped by High School Graduating Class



Note: The proficiency rate is the total percentage of students who are proficient or distinguished.
Source: Staff analysis of data from Commonwealth. Dept. of Ed. *Kentucky Performance*.

Some limitations to this cohort analysis should be noted. Cohort data are rarely perfectly comparable over time. in their student populations. KCCT is not vertically scaled; different pools of test items are used for each grade. Changes to KCCT limit comparability.

Some limitations to this cohort analysis should be noted.

- Cohort data are rarely perfectly comparable over time. The composition of students changes as students drop out, die, move into or out of the state, or transfer into or out of private schools or home schooling. Of course, schools and districts are held accountable for assessment trends despite such changes in their student populations.

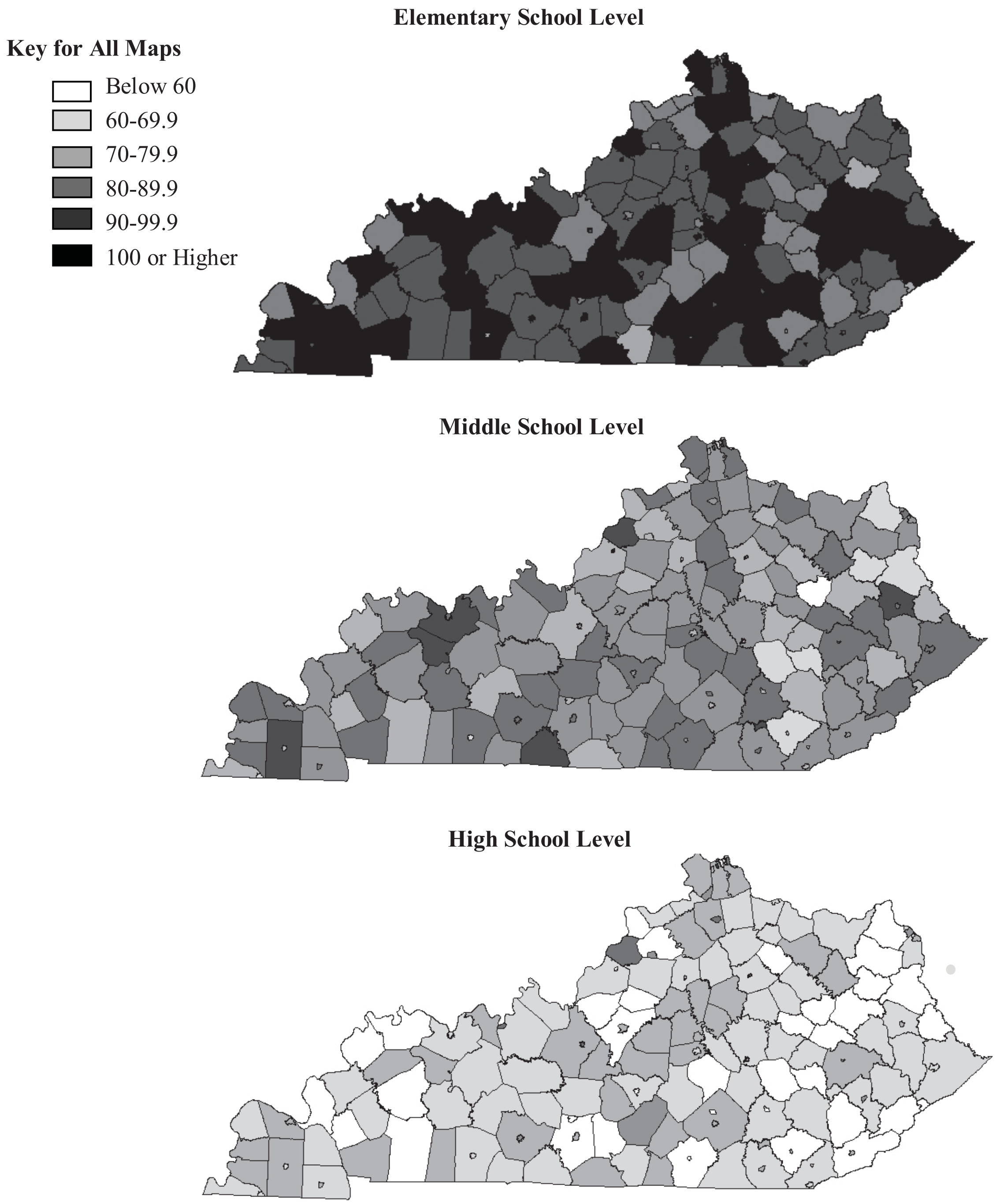
- KCCT is not vertically scaled; different pools of test items are used for each grade.
- Changes to KCCT limit comparability, especially the extensive changes made in 2007. Compared to earlier KCCT tests, the 2007 KCCT tested more grades each year, changed the weights given to each components of the annual school accountability index, implemented a new alternate assessment system for students who were deemed unable to take the regular assessment, and set new performance standards by grade and content area (Commonwealth. Dept. of Ed. *2006-2007 Technical Report* 6-16, 163).

KCCT Results by District

KCCT results mapped by district show higher performance in younger grades, reflecting, at least in part, cohort differences. High elementary index values are more evenly distributed across districts than high values of the middle and high school indices.

Figure 2.K maps KCCT results by district. Lighter shades represent lower achievement, while darker shades represent higher achievement. Performance is higher in the younger grades, which reflects, at least in part, the cohort patterns discussed earlier in relation to Figure 2.J. It should also be noted that high values of the elementary index are more evenly distributed across districts than high values of the middle and high school indices.

Figure 2.K
KCCT Mathematics Index, 2008



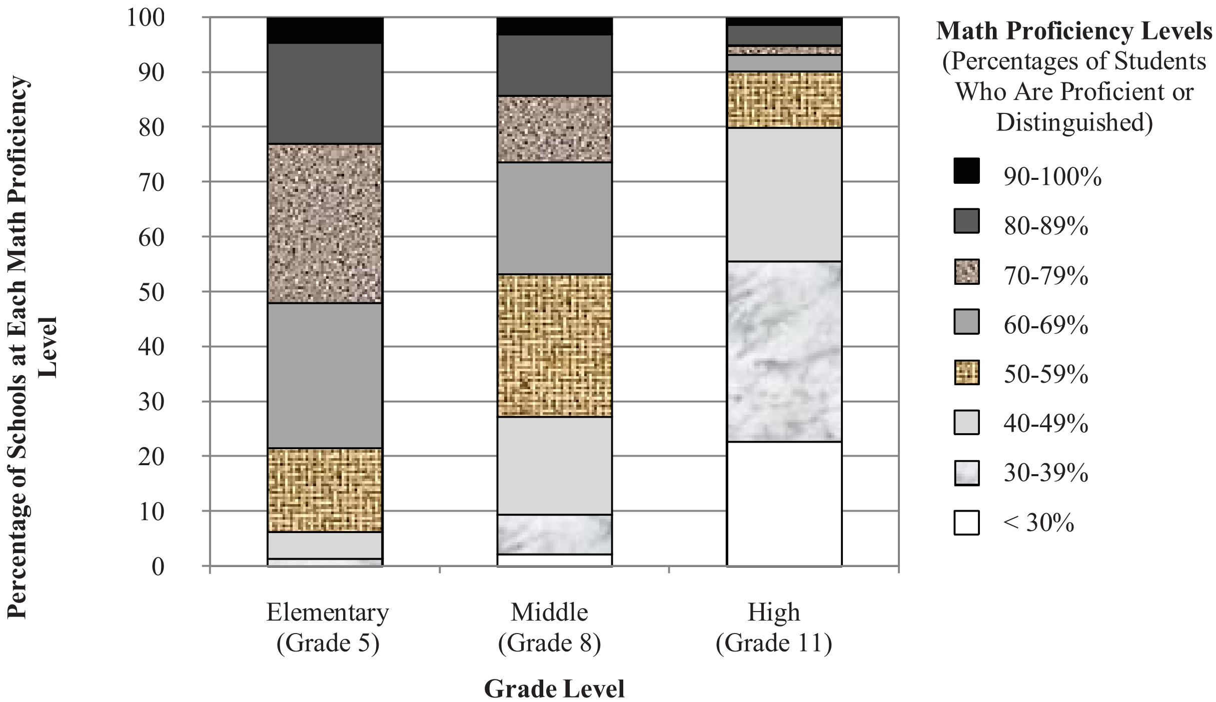
Note: The Anchorage Independent, East Bernstadt Independent, Science Hill Independent, Southgate Independent, and Westpoint Independent districts have no high school index.
Source: Staff compilation of unpublished data from the Kentucky Department of Education.

School Proficiency Rates

Cohort effects have implications for middle and high schools. In 8 out of 10 high schools, less than half of the students are proficient in math. The same is true of 3 out of 10 middle schools and a fraction of elementary schools.

Figure 2.L shows the proportion of schools at each proficiency level broken out by elementary, middle, and high. The patterns here show how the cohort differences discussed earlier impact individual schools. An argument can be made that high schools, whose students have had less time to benefit from the gradual changes that result from assessment and accountability, are struggling the most; in 8 out of 10 high schools, less than half of the students are proficient in mathematics. The same is true of 3 out of 10 middle schools and a fraction of elementary schools (Commonwealth. Dept. of Ed. *Kentucky Performance* and Kentucky Education).

Figure 2.L
Distribution of Schools by Mathematics Proficiency Levels for Grades 5, 8, and 11
Kentucky Core Content Test, FY 2008



Source: Commonwealth. Dept. of Ed. *Kentucky Performance*.

Educational Planning and Assessment System

ACT, Inc. provides minimum scores, or benchmarks, that predict college success. On the ACT, a 22 indicates a 75 percent chance of earning a C and a 50 percent chance of earning a B in college algebra.

The Educational Planning and Assessment System (EPAS) consists of EXPLORE, PLAN, and the ACT. These tests were designed by ACT, Inc. to gauge students' progress toward a set of college-readiness standards that were developed by ACT, Inc.[3] For each test, ACT, Inc. identified the minimum scores, or benchmarks, on each test that predict future success. On the ACT exam, students scoring 22 have a 75 percent chance of earning a C and a 50 percent chance of earning a B in a college algebra class.

CPE used Kentucky data to establish two additional ACT benchmarks: students scoring 27 are ready for college calculus, and those scoring 18 are ready for general college math, but not algebra; those scoring below 18 need noncredit developmental courses.

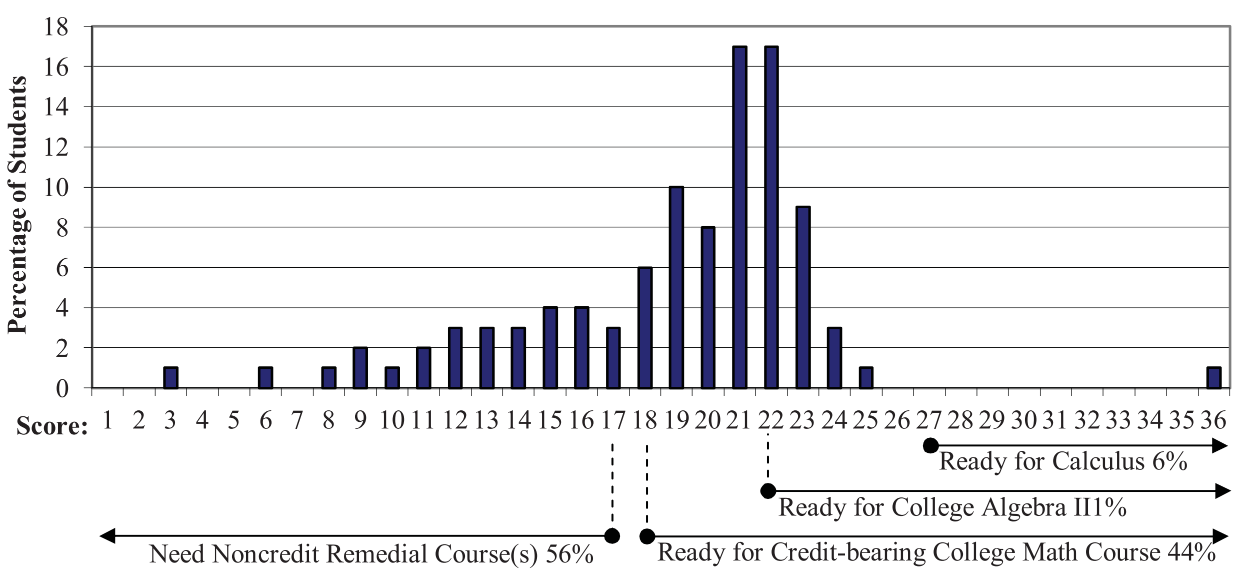
Kentucky's CPE used Kentucky assessment data and college grades to establish two other ACT benchmarks: students scoring 27 are ready for a college calculus course, and those scoring 18 are ready for a college course in general mathematics, but not college algebra. Those scoring less than 18 need one or more developmental (remedial) courses that do not earn college credit.

ACT Scores for 11th Graders

Fewer than half of Kentucky 11th graders in FY 2009 were ready for a credit-bearing college course. Only 21 percent were ready for college algebra and 6 percent were ready for college calculus.

At the time this report was written, all Kentucky 11th graders had taken the ACT for 2 years—FY 2008 and FY 2009. In FY 2009, as Figure 2.M shows, if all of these 11th graders went to college, 56 percent would need to take remedial courses that earn them no college credit. Only 6 percent of 11th graders indicated readiness for college calculus, and 21 percent were ready for college algebra.

Figure 2.M
ACT Mathematics Scores, Kentucky 11th Graders, Fiscal Year 2009



Note: Data summarizes results of 42,929 Kentucky 11th graders who took the ACT. When no visible bar is above a score, less than 1 percent of students received that score. The cluster of students at the top test score is commonly seen in test score distributions; it includes students who could have scored higher if the top score had been higher.
Source: Staff compilation of data from ACT. *ACT State*.

---
[3] EPAS college-readiness standards can be found in Appendix D.

The EXPLORE and PLAN benchmarks indicate a 50 percent chance of going on to score at or above the college algebra benchmark on the ACT. No benchmarks have been established that correspond to a 27 or 18 on the ACT.

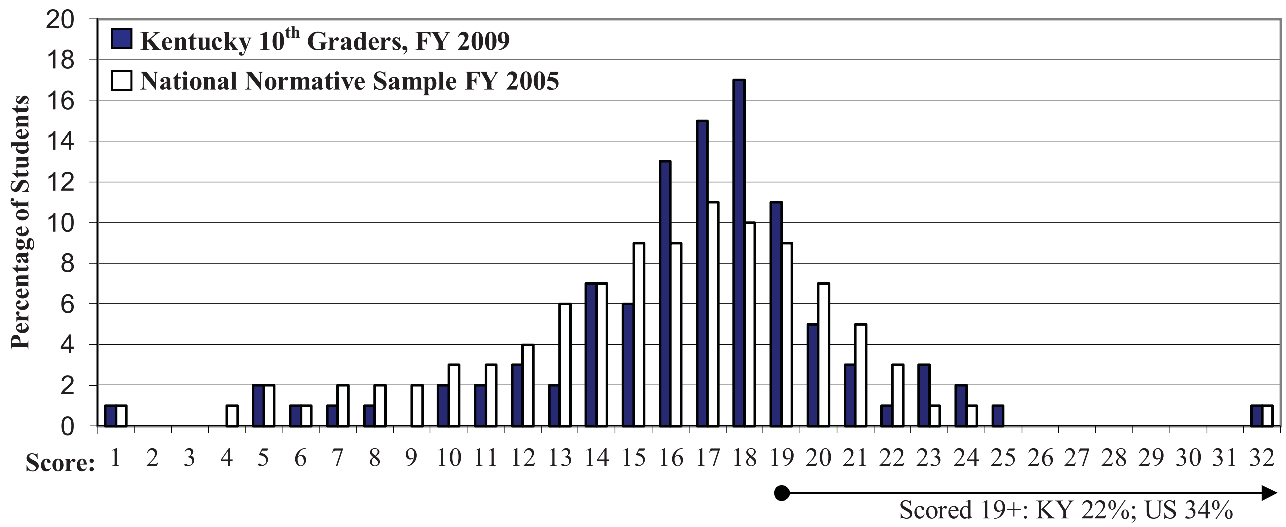
EXPLORE and PLAN—modified versions of the ACT—are designed to gauge whether 8th graders and 10th graders, respectively, are making adequate progress toward college readiness. The benchmarks that ACT, Inc. set for these tests indicate a 50 percent chance of going on to score at or above the college algebra benchmark for the ACT. Currently, no benchmarks have been established that correspond to a 27 or 18 on the ACT.

PLAN Scores for 10th Graders

Less than one-fourth of 10th graders appeared to be on track to eventually succeed in college algebra.

As Figure 2.N shows, 22 percent of Kentucky's 10th graders scored at or above 19, which indicates a 50 percent chance of later meeting the college algebra benchmark on the ACT. This is close to the 20 percent of 11th graders who met the corresponding ACT benchmark.

Figure 2.N
PLAN Mathematics Scores, Kentucky 10th Graders, Fiscal Year 2009 Compared to National Normative Sample Fiscal Year 2005



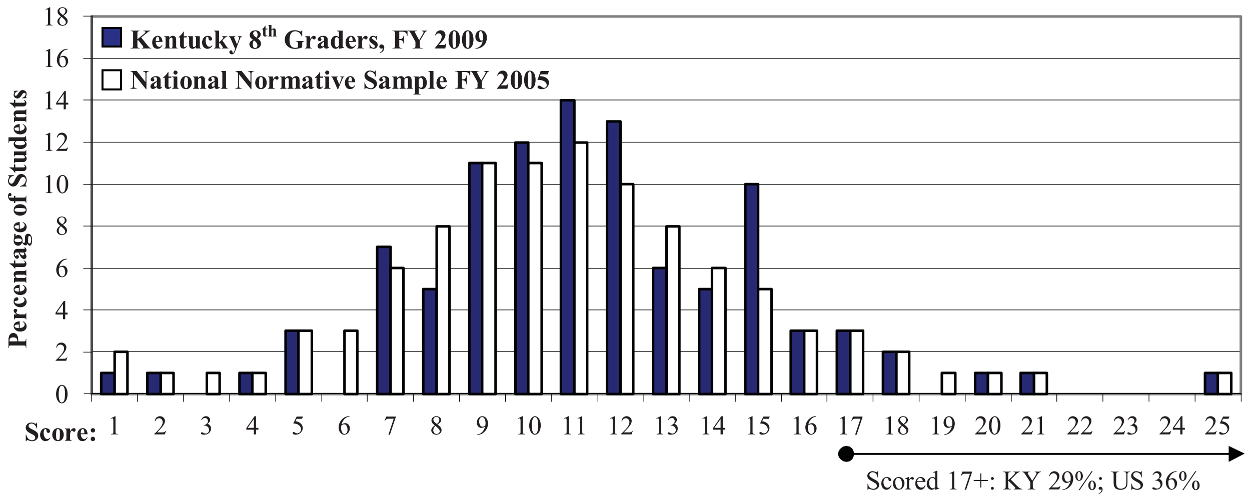
Note: Data summarizes results of 49,589 Kentucky 10th graders who took the PLAN exam in the fall of 2009 and 4,356 nationally representative 10th graders to whom ACT administered the exam in the fall of 2005 in order to establish national norms. When no visible bar is above a score, less than 1 percent of students received that score. The cluster of students at the top test score is commonly seen in test score distributions; it includes students who could have scored higher if the top score had been higher.
Source: Staff compilation of data from ACT. *PLAN.*

EXPLORE Scores for 8th Graders

Less than one-third of 8th graders appeared to be on track to eventually succeed in college algebra.

As Figure 2.O shows, in FY 2009, 29 percent of 8th graders met the EXPLORE benchmark, which indicates a 50 percent chance of going on to meet the ACT benchmark for college algebra. These 8th graders will take the ACT in 2011.

Figure 2.O
EXPLORE Mathematics Scores, Kentucky 8th Graders, Fiscal Year 2009 Compared to National Normative Sample Fiscal Year 2005



Note: Data summarizes results of 48,347 Kentucky 8th graders who took the EXPLORE exam in the fall of 2009 and 4,879 nationally representative 8th graders to whom ACT administered the exam in the fall of 2005 in order to establish national norms. When no visible bar is above a score, less than 1 percent of students received that score. The cluster of students at the top test score is commonly seen in test score distributions; it includes students who could have scored higher if the top score had been higher.
Source: Staff compilation of data from ACT. *EXPLORE.*

EPAS Trends

The EXPLORE and PLAN exams have been administered in Kentucky for 3 consecutive years, and the ACT exam for 2 consecutive years. Kentucky's trends over the past 2 or 3 years cannot be compared to national trends because ACT, Inc. has not updated its 2005 national normative sample for EXPLORE and PLAN, and there is no normative sample for the ACT.

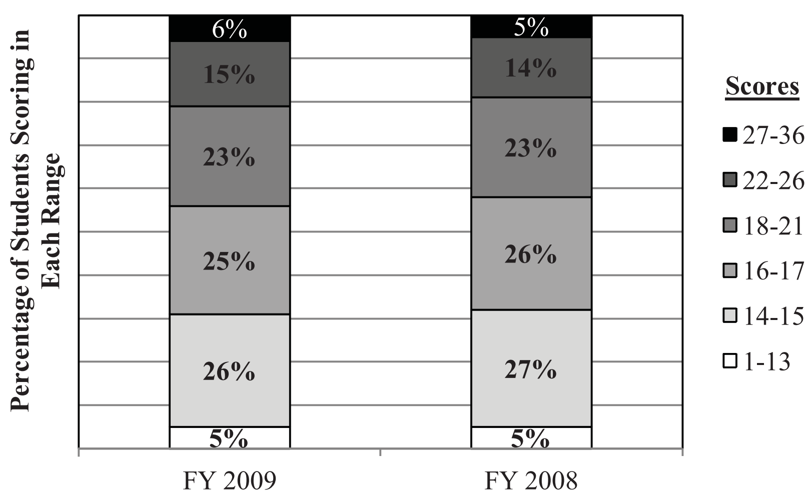
Scores have not changed much in the short time that Educational Planning and Assessment System exams have been administered.

As Figure 2.P shows, ACT scores in FY 2009 differed only slightly from those in FY 2008. Similarly, Figures 2.Q and 2.R show that EXPLORE and PLAN scores have changed little during the 3 years these tests have been administered.

A cohort analysis of test scores suggests that EXPLORE and PLAN are reasonably good predictors of how many students will meet the ACT benchmark for college algebra readiness.

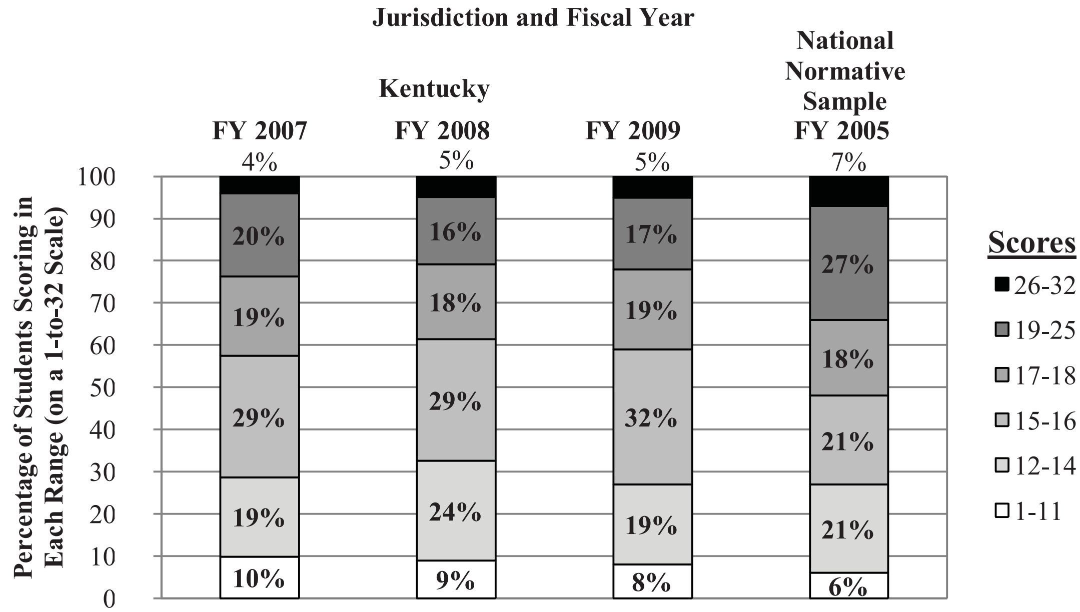
These trends suggest that EXPLORE and PLAN are reasonably good predictors of how many students will meet the ACT benchmark for college algebra readiness. In the fall of FY 2007, 23 percent of 10th graders met the PLAN benchmark; when this cohort took the ACT in the spring of FY 2008, 20 percent met the ACT benchmark. When another cohort of 10th graders took PLAN in the fall of FY 2008, 21 percent met the PLAN benchmark. In the spring of FY 2009, 21 percent of this cohort of students met the ACT benchmark.

Figure 2.P
Percent Distribution of Grade 11 ACT Mathematics Scores, Kentucky
Spring 2008 and Spring 2009



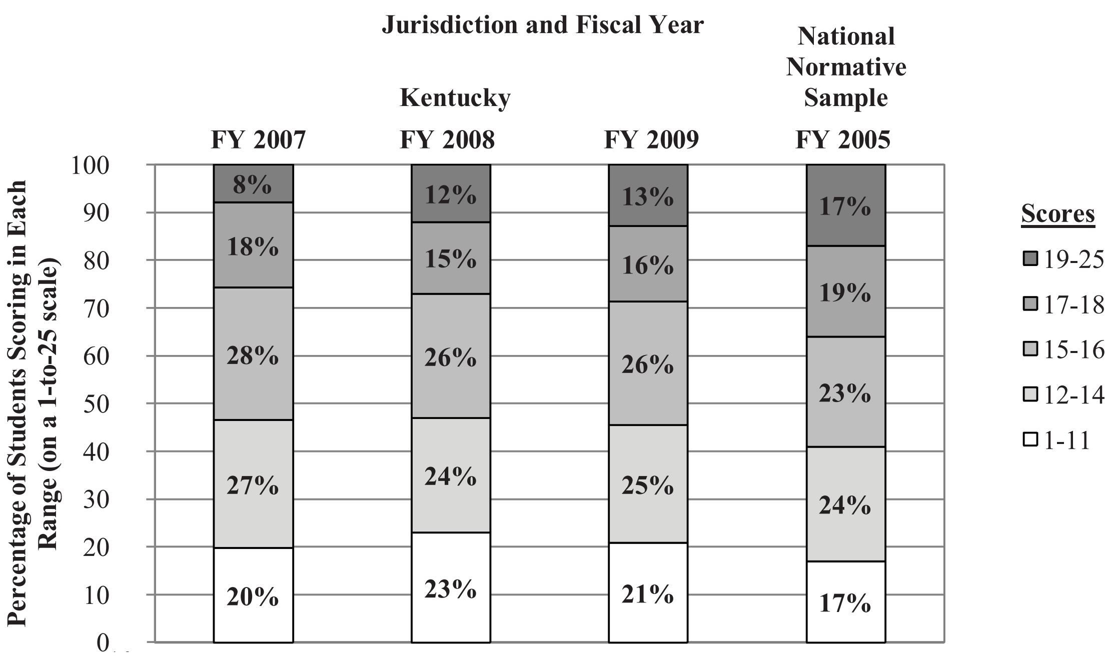
Source: Staff compilation of data from ACT. *ACT State*.

Figure 2.Q
Percent Distribution of Grade 10 PLAN Mathematics Scores
Kentucky Fall 2007-Fall 2009 and National Normative Sample Fall 2005



Note: Percentages may not add to 100 percent due to rounding.
Source: Staff compilation of data from ACT. *PLAN.*

Figure 2.R
Percent Distribution of Grade 8 EXPLORE Mathematics Scores
Kentucky Fall 2007-Fall 2009 and National Normative Sample Fall 2005



Note: Percentages may not add to 100 percent due to rounding.
Source: Staff compilation of data from ACT. *EXPLORE.*

Knowledge and Skills in Specific Mathematics Subdomains

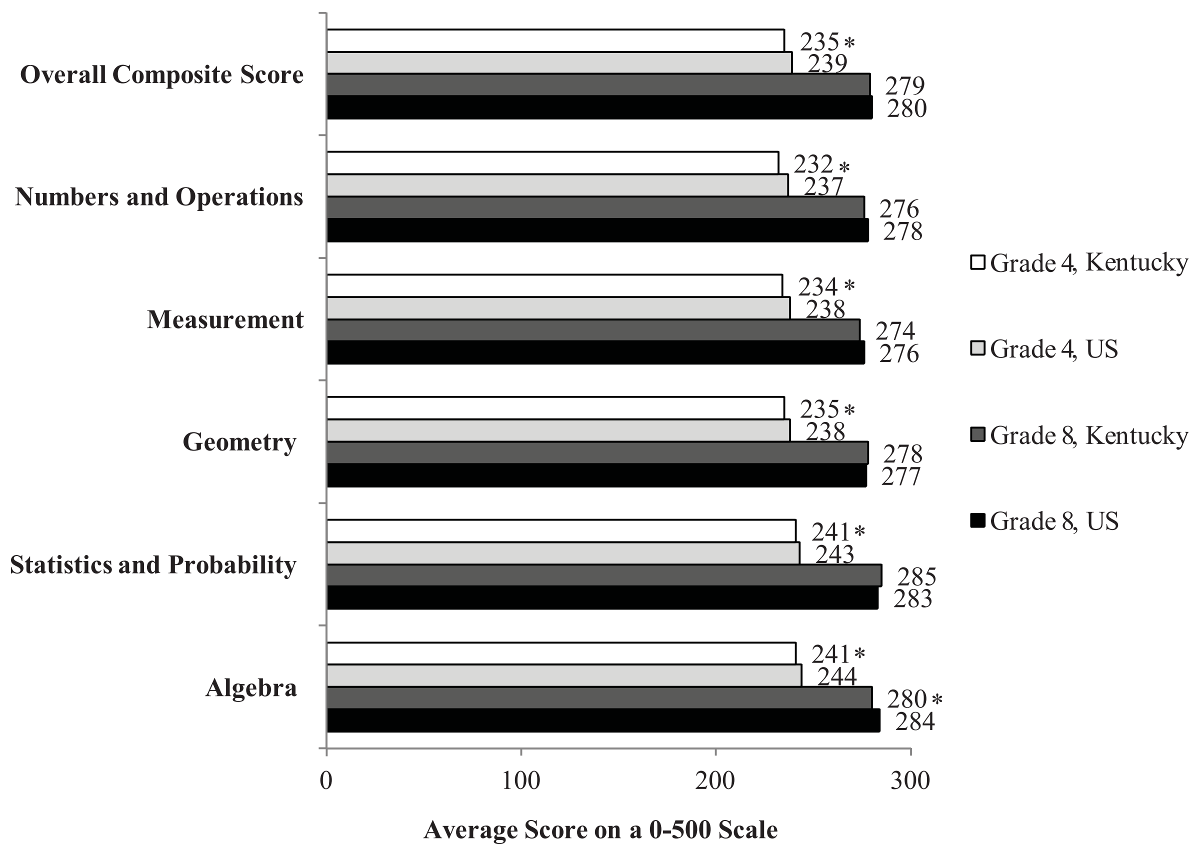
NAEP Results by Subdomain

Mathematics proficiency can vary by mathematics content area, which is called a subdomain in Kentucky. Results are reported by subdomain for both NAEP and KCCT. However, since test items vary from grade to grade and from year to year within a grade, it is difficult to draw clear conclusions.

Kentucky 4th graders performed below the national average in all mathematics subdomains. Kentucky 8th graders fell short in algebra, but were on par with the nation in the numbers and operations, measurement, geometry, and statistics and probability subdomains.

As Figure 2.S shows, Kentucky 4th graders showed a small but significant shortfall compared to the national average in all mathematics subdomains. Kentucky's 8th graders were on par with the nation in all subdomains except algebra, where Kentucky's 8th graders fell short of the nation by a small but statistically significant amount.

Figure 2.S
NAEP Mathematics Results by Subdomain, 2007



Note: * indicates statistically significant differences between Kentucky and the nation (p<.05).
Source: US. Dept. of Ed. Inst. Natl. *NAEP Data*.

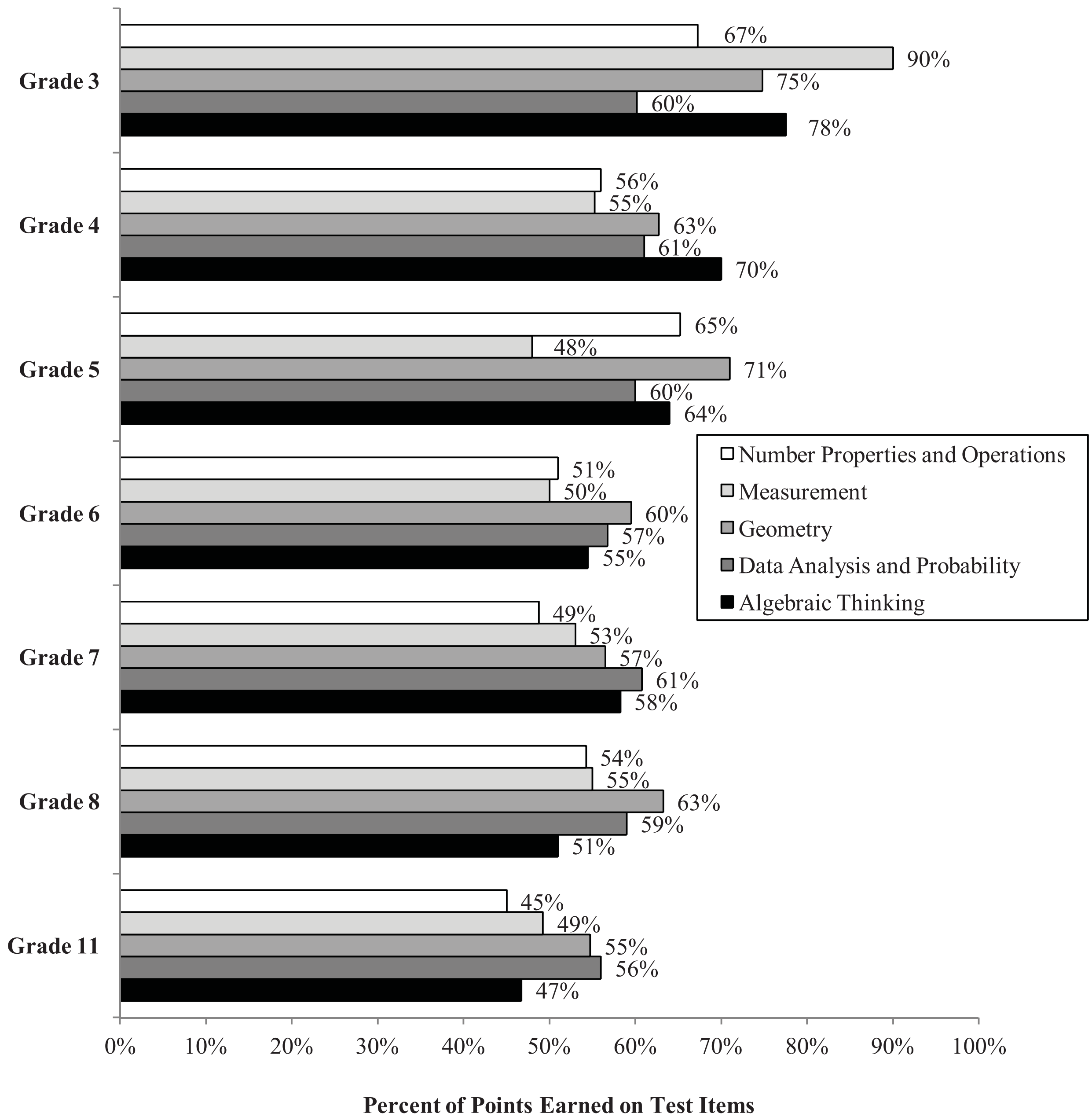
KCCT Results by Subdomain

The percentage of available points earned in each subdomain shown in Figure 2.T reflects the number of multiple-choice questions answered correctly and the number of points earned on open-response questions. Comparisons should not be made between grades because grade-specific tests were not designed for such comparisons. Instead, this figure is meant to compare subdomain performance within each grade.

Whereas NAEP results showed approximately the same level of mastery across all subdomains, KCCT results show more variation. Kentucky students show relatively less mastery of number properties and operations, which are fundamental to a firm grasp of mathematics.

Although KCCT's subdomains have many similarities to NAEP's, the test results by subdomain differ somewhat. Whereas NAEP results showed approximately the same level of mastery across all subdomains, KCCT results showed more variation. It is somewhat worrisome that Kentucky students show relatively less mastery of number properties and operations, which are fundamental to a firm grasp of mathematics.

Figure 2.T
Percentage of Points Earned on KCCT Mathematics Test by Subdomain and by Grade, Spring 2008



Note: This figure is intended for comparisons among subdomains within each grade; subdomain performance should not be compared across grades because the grade-specific tests are not designed for such comparisons. Percentages were calculated in three steps: 1) open-response scores were summed and divided by the total possible points (4 per item); 2) the number of multiple-choice items answered correctly was divided by the total number of multiple-choice items; and 3) the quotients from steps one and two were averaged and then multiplied by 100. For grade 3, the average in step three assigned a weight of 0.33 to open-response items and 0.67 to multiple-choice items, in keeping with the formula for determining school accountability (703 KAR 5:020).
Source: Commonwealth. Dept. of Ed. *Kentucky Performance*.

Advanced Placement

AP courses and exams provide high school students early access to college-level learning. They increase students' chances of getting into college, earning college credits, and being placed in higher-level college courses.

Advanced Placement courses and exams provide high school students early access to college-level learning. Most colleges and universities use AP exam results in the admissions process to gauge a student's ability and to award college credit or placement into higher-level college courses (College Board. About). It is important to note that students may take an AP course without taking the exam or take an exam without taking a course. In FY 2009, approximately 6,300 Kentucky students were enrolled in AP calculus or statistics courses. FY 2009 ACT exam data were not available at the time of this report, but in FY 2008, 3,700 took an official AP calculus or statistics exam (College Board. AP Courses).

The composite score for each AP exam reflects the grade that a student could be expected to earn in a college course. The score is reported on a scale of 1 to 5 that corresponds to the letter grades F, D, C, B, and A, respectively. Statistical reports often focus on scores of 3 or higher because these correspond to passing grades eligible for college credit (College Board. AP Courses).

AP math topics include calculus, computer science, and statistics.

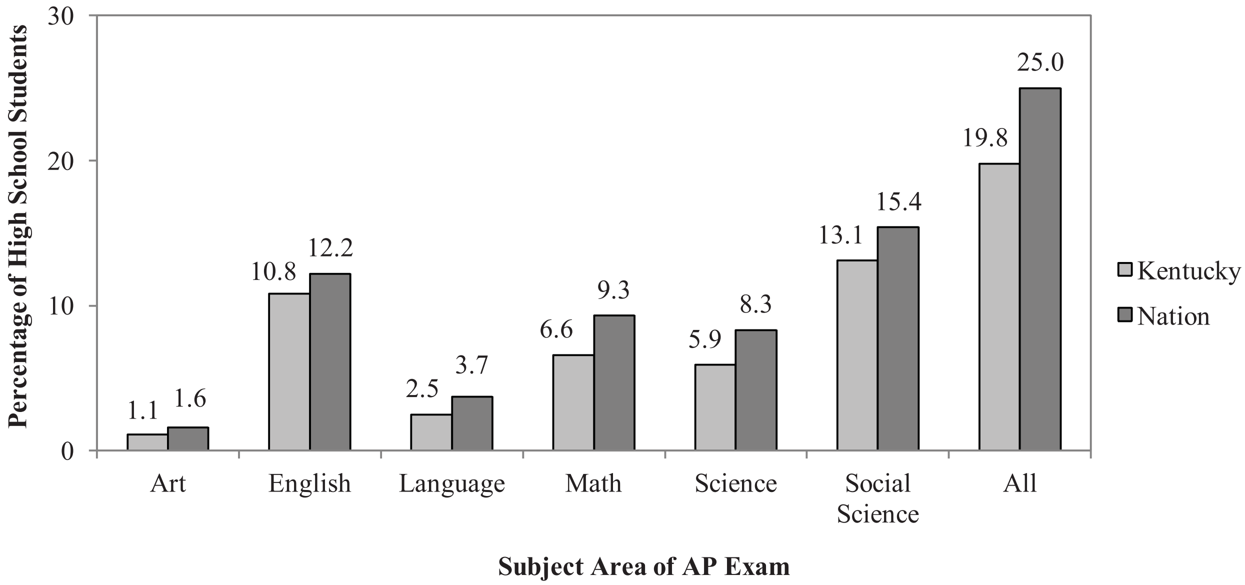
The College Board considers the following AP topics to be mathematics:

- The exam called Calculus AB covers topics typically included in about two-thirds of a full-year college-level calculus sequence.
- Calculus BC covers topics typically included in a full year of college calculus.
- Computer Science A assumes knowledge of basic algebra and is meant to be the equivalent of a first-semester course in computer science.
- Computer Science AB includes more formal and in-depth study of algorithms, data structures, and data abstraction.
- Statistics is equivalent to a one-semester introductory college statistics course (College Board. AP Courses).

In 2008, 6.6 percent of Kentucky's graduates had taken an AP math exam, compared to 9.3 percent of the nation's graduates.

As Figure 2.U shows, 6.6 percent of Kentucky's 2008 graduating class had taken at least one AP mathematics exam at some time during high school, compared to the national rate of 9.3 percent.

Figure 2.U
Percentages of Kentucky Students Who Took at Least One AP Exam During High School, by Subject Area, Compared to the Nation, Fiscal Year 2008



Note: Mathematics includes Calculus AB, Calculus BC, Computer Science A, Computer Science AB, and Statistics.
Source: College Board. *The 5th Annual AP Report to the Nation—Kentucky Supplement* 3. Copyright (c) 2009. <www.collegeboard.com>. Reproduced with permission.

Only a fraction of the AP exams taken cover math topics.

Table 2.7 compares Kentucky to the nation in terms of AP exam activity in all subjects and in mathematics specifically. In FY 2008, approximately 1 in 4 of Kentucky's 11th and 12th graders took some type of AP exam, compared to about 1 in 3 students nationwide. However, in both Kentucky and the nation, only a fraction of the exams were in mathematics.

Table 2.7
AP Exam Participation as a Percent of 11th and 12th Graders
Kentucky and US, Fiscal Year 2008

	Took Exams		Scored 3, 4, or 5 (Eligible for College Credit)		Average Score (on 1-to-5 Scale)	
	KY	US	KY	US	KY	US
All Subjects	25.1%	34.0%	11.8%	18.9%	2.52	2.78
All Math	3.5%	5.1%	2.0%	3.2%	2.88	3.04
Calculus AB	2.2%	2.6%	1.1%	1.6%	2.70	2.97
Calculus BC	0.3%	0.8%	0.2%	0.7%	3.58	3.66
Computer Science A	0.1%	0.2%	0.1%	0.1%	3.65	2.86
Computer Science AB	0.0%	0.1%	0.0%	0.0%	3.46	3.52
Statistics	0.8%	1.4%	0.5%	0.8%	2.98	2.83

Note: The exam called Calculus AB covers topics typically included in about two-thirds of a full-year college-level calculus sequence. Calculus BC covers topics typically included in a full year of college calculus. Computer Science A assumes knowledge of basic algebra and is meant to be the equivalent of a first-semester course in computer science. Computer Science AB includes more formal and in-depth study of algorithms, data structures, and data abstraction. Statistics is equivalent to a one-semester introductory college statistics course.
Source: College Board. Summary.

If efforts to increase AP participation are successful, policy makers should expect an initial decline in average scores. Early evidence suggests that a program called AdvanceKentucky may increase both attempts and pass rates.

As in other states, Kentucky is exploring ways to increase the number of students taking AP mathematics courses and exams. If efforts to increase participation are successful, policy makers should expect to see a decline in average scores. This phenomenon has been observed for other student performance measures, such as the ACT, so it will likely happen with AP exams.

However, early evidence suggests that at least one initiative to increase AP exam participation may be succeeding in increasing both attempts and passing rates. A program called AdvanceKentucky, in partnership with the National Mathematics and Science Initiative, KDE, and the Kentucky Science and Technology Corporation, has been working with high schools to boost AP participation through support and incentives. AdvanceKentucky reports that in the 12 schools participating in FY 2009, the number of mathematics passing scores increased by 80 percent, and the number of mathematics exams attempted increased by 57 percent. At the time of this report, detailed statewide data have not been publicly released, so further analysis is not possible.

AP by Student Characteristics

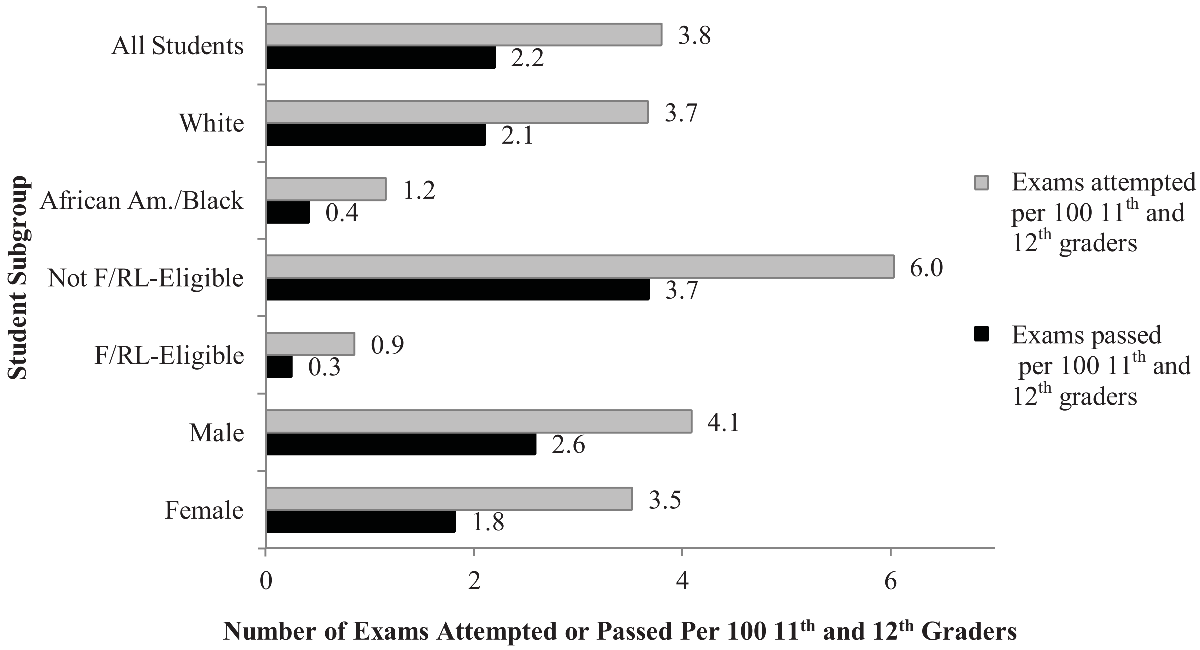
There is wide variation in exam taking and pass rates, depending on student characteristics.

One objective of AdvanceKentucky is to increase participation in AP courses and exams, mathematics, science, and English by groups that are underrepresented, such as low-income, minority, and female students. Figure 2.V shows the variation in exam taking and exam passing by student characteristics. In order to provide a point of reference, the first pair of bars shows rates for all students. Out of every 100 students enrolled in 11th and 12th grade, 3.8 AP mathematics exams were attempted, and 2.2 were passed. However, as this figure shows, when AP data are analyzed by race, gender, and free and reduced-price lunch, it is clear that not all subgroups participated at the same rate.

The biggest gap is by income. Students eligible for free and reduced-price lunches are far less likely to attempt or pass an AP exam. Racial gaps are also large. Gender gaps were not as large, but males made more attempts and had higher pass rates.

The biggest achievement gap is by eligibility for free and reduced-price lunch; for every 100 ineligible students, 6.03 exams were attempted and 3.68 were passed. In contrast, for every 100 eligible students, only 0.85 exams were attempted and 0.25 were passed. This achievement gap for this subgroup is noteworthy, as 54 percent of Kentucky students are eligible for free and reduced-price lunch (Commonwealth. Dept. of Ed. Qualifying). Gaps between the major racial groups were also large in FY 2008; the attempt and pass rates for whites were more than triple the rates for African Americans. The gender gap was not as large as the poverty and race gaps, but males made more attempts and had higher pass rates than females. For all subgroups, the number of exams passed per 100 students was higher than it was in 2007. Attempts, too, increased for all groups except African Americans.

Figure 2.V
Advanced Placement Mathematics Exams Attempted and Passed Per 100 Students by Subgroups, Kentucky, Fiscal Year 2008



Note: Mathematics AP exams include Calculus, Statistics, and Computer Science. F/RL-Eligible means a student's family income qualifies for free or reduced-price lunch through the National School Lunch Program.
Source: Unpublished data from the Kentucky Department of Education.

AP Variations from School to School

AP exam activity is not uniform across the state. Fourteen percent of high schools had no students attempting AP math exams, and almost a third had no passing scores in math.

AP exam activity is not uniform across the state. As Tables 2.8 and 2.9 show, during the 3-year period from FY 2006 through FY 2008, 14 percent of Kentucky's 225 high schools had no students attempting AP mathematics exams, and almost a third (31 percent) had no passing scores in mathematics.

Table 2.8
Advanced Placement Exams Attempted Per 100 Students Enrolled in 11th and 12th Grades Distribution by Kentucky High School, Fiscal Year 2006-Fiscal Year 2008

Math Exam Attempts Per 100 Students	Percentage of High Schools		
	FY 2006	FY 2007	FY 2008
None	24	23	24
0.1-0.9	10	13	14
1-1.9	17	19	14
2-2.9	17	9	13
3-3.9	7	10	9
4-4.9	6	8	8
5-5.9	5	5	2
6 or more	15	14	16
Total	100	100	100

Source: Staff analysis of unpublished data from the Kentucky Department of Education.

Table 2.9
Advanced Placement Exam Passing Scores Per 100 Students Enrolled in 11th and 12th Grades, Distribution by Kentucky High School, Fiscal Year 2006-Fiscal Year 2008

Math Exam Passing Scores Per 100 Students	Percentage of High Schools		
	FY 2006	FY 2007	FY 2008
None	43	46	45
0.1-0.9	23	22	23
1-1.9	12	14	10
2-2.9	7	4	5
3 or more	15	14	16
Total	100	100	100

Source: Staff analysis of unpublished data from the Kentucky Department of Education.

Achievement Gaps

Table 2.10 provides an overview of achievement gaps by grade based on the FY 2008 KCCT mathematics index, which is on a scale of 0 to 140, with higher values indicating greater mastery of content. All gaps are large except by gender.

By comparison, NAEP scores have small gender gaps, too, but in the opposite direction; males score slightly higher than females on NAEP but slightly lower than females on KCCT. Gender gaps on both tests have been consistently small over time and are often not statistically significant.

Students with disabilities, poor students, African Americans, and students with limited English proficiency have significantly lower achievement test results.

Students with disabilities, impoverished students (as indicated by eligibility for free and reduced-price lunch), African Americans, and students with limited English proficiency face serious obstacles to achievement.

Table 2.10
Achievement Gaps by Grade, KCCT Mathematics Index, Fiscal Year 2008

	Grade						
Subgroup	**3**	**4**	**5**	**6**	**7**	**8**	**11**
Gender							
Females	101.6	98.5	92.6	93.8	87.7	80.2	69.7
Males	100.2	98.0	90.6	87.6	82.9	78.5	65.8
Gender Gap	1.4	0.5	2.0	6.2	4.8	1.7	3.9
Free and Reduced-price Lunch							
Not F/RL Eligible	111.2	109.1	103.3	101.6	97.2	91.4	76.8
F/RL Eligible	92.1	88.8	81.2	80.4	73.5	67.0	54.0
Poverty Gap	19.0	20.3	22.1	21.2	23.8	24.3	22.8
Race							
White	103.4	100.9	94.4	93.6	88.1	82.4	70.3
African American	82.4	78.7	70.5	68.1	63.6	56.2	46.0
Race Gap	21.0	22.2	23.9	25.4	24.5	26.2	24.3
English Proficiency							
Nonlimited English Proficiency	101.1	98.5	91.9	90.8	85.5	79.6	67.9
Limited English Proficiency	89.9	85.3	76.7	71.6	66.3	57.6	49.4
English Proficiency Gap	11.2	13.2	15.2	19.2	19.2	22.0	18.5
Disability Status							
No Disability	105.0	102.2	96.1	95.2	89.3	83.9	71.8
Students with Disability	76.9	75.3	65.5	61.7	58.5	49.1	33.8
Disability Status Gap	28.1	26.9	30.6	33.5	30.8	34.8	38.0

Note: The KCCT mathematics index is on a scale of 0 to 140, with higher values indicating greater mastery of content. “F/RL” means free and reduced-price lunch.
Source: Commonwealth. Dept. of Ed. *Kentucky Performance*.

Conclusions

Despite improvements, the math knowledge and skills of Kentucky students are still below the national average. It is of concern that a sizable portion of Kentucky's high school graduates are not ready for college and careers. Achievement gaps are substantial with respect to income, race, English language proficiency, and disability.

Kentucky students' mathematics knowledge and skills have been improving over time, but are still at levels below the national average. It is of concern that, judging from the college-readiness exam data, a sizable portion of Kentucky's high school graduates are not ready for the postsecondary education and careers of today, much less for the increasing demands of tomorrow's workplace. Achievement gaps are substantial with respect to income, race, English language proficiency, and disability.

Chapter 3

Course Taking and High School Graduation Requirements

This chapter examines the relationship between course taking and achievement, patterns of course taking in Kentucky, and state high school graduation requirements. Comparisons to other states are provided where available. Given the changes in graduation requirements scheduled for Kentucky's class of 2012, the chapter ends with a discussion of lessons that can be learned from other states' experiences with changing requirements.

Kentucky students must earn credit for three high school math courses, including Algebra I and Geometry. Afterward, students can choose to take no more math. This will change with the graduating class of 2012, when credit for Algebra II must also be earned and students must take math every year.

Kentucky's high school graduates are required to have earned credit for three high school mathematics courses, including Algebra I and Geometry; after fulfilling these requirements, students can choose to take no more mathematics for the rest of their time in high school. This will change with the graduating class of 2012. Students will need to take mathematics in all years of high school and will need to earn credit for Algebra II in addition to Algebra I and Geometry.

Kentucky's more stringent mathematics requirements in 2012 are intended to boost readiness for college and careers. Taking more-advanced mathematics courses is associated with higher test scores. It stands to reason that students gain more knowledge and skills from advanced courses than less-demanding courses. However, this causal relationship has not been established definitively. Part of the reason for higher mathematics scores is that the students who choose to take advanced mathematics are those with more mathematics skills and motivation. Some of this self-selection bias can be removed by taking into account prior achievement and such background factors as income, gender, and race. However, without carefully controlled experimental designs, researchers cannot measure the precise impact of advanced courses alone.

Relationship Between Course Taking and Achievement

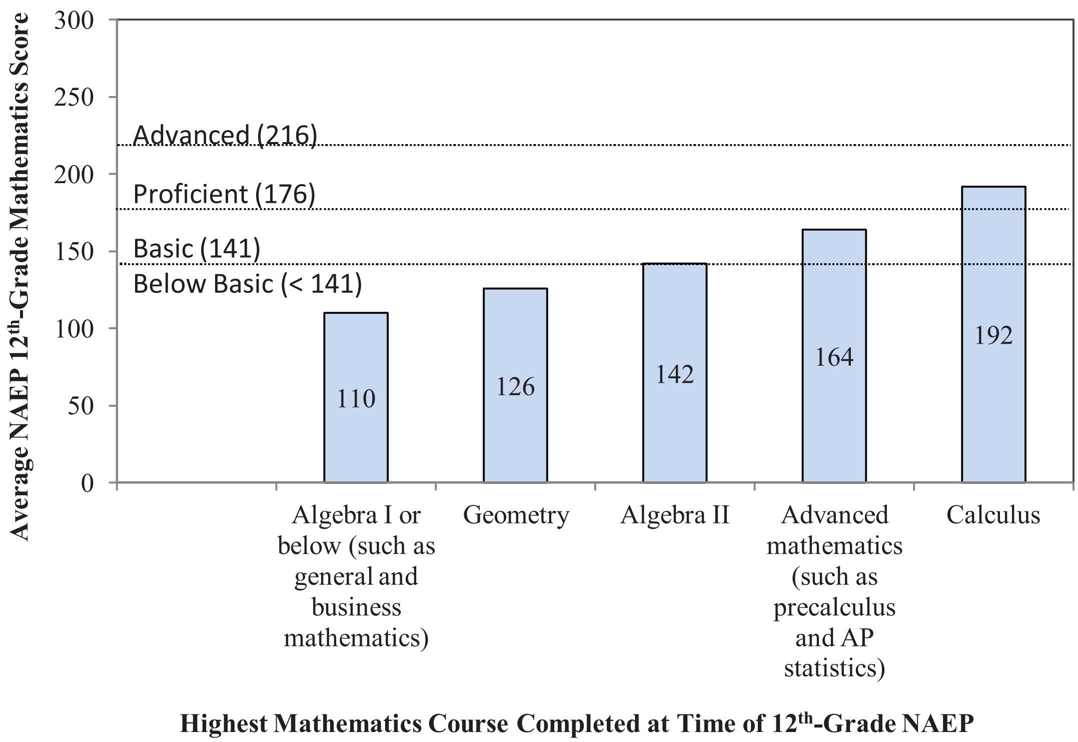
Many studies have found a link between demanding math courses and higher achievement test scores, even after controlling for prior student achievement and socioeconomic status.

Many studies have found that students who take more-demanding mathematics courses usually have higher achievement test scores, even after controlling for such factors as prior student achievement and socioeconomic status (ACT. *Benefits*; Epstein; US. Dept. of Ed. Inst. Natl. *Answers* and *Mathematics Coursetaking*).

Rigorous courses are associated with higher NAEP scores. However, only students taking calculus scored proficient on the 12th-grade NAEP math test. Passing Algebra II does not appear to be enough to ensure proficiency.

Figure 3.A reports the average NAEP score by the highest mathematics course that 12th graders had completed at the time of the NAEP exam, according to student transcripts. Only the group of students that completed calculus had an average score at or above the cut score indicating proficiency. The fact that those who took Algebra II scored only at the basic level raises questions as to whether Kentucky's plans to require credit for Algebra II will be enough to ensure that students are ready for postsecondary education and careers. Scores on the ACT show a similar pattern, with average scores for those taking Algebra II below the benchmark for college algebra; those taking advanced courses beyond Algebra II met the benchmark (ACT. "College").

Figure 3.A
Highest Level of Mathematics Course Completed Based on Student Transcripts and NAEP 12th-Grade Mathematics Scores, US, 2005



Source: US. Dept. of Ed. Inst. Natl. *NAEP Data* and The NAEP Mathematics Achievement.

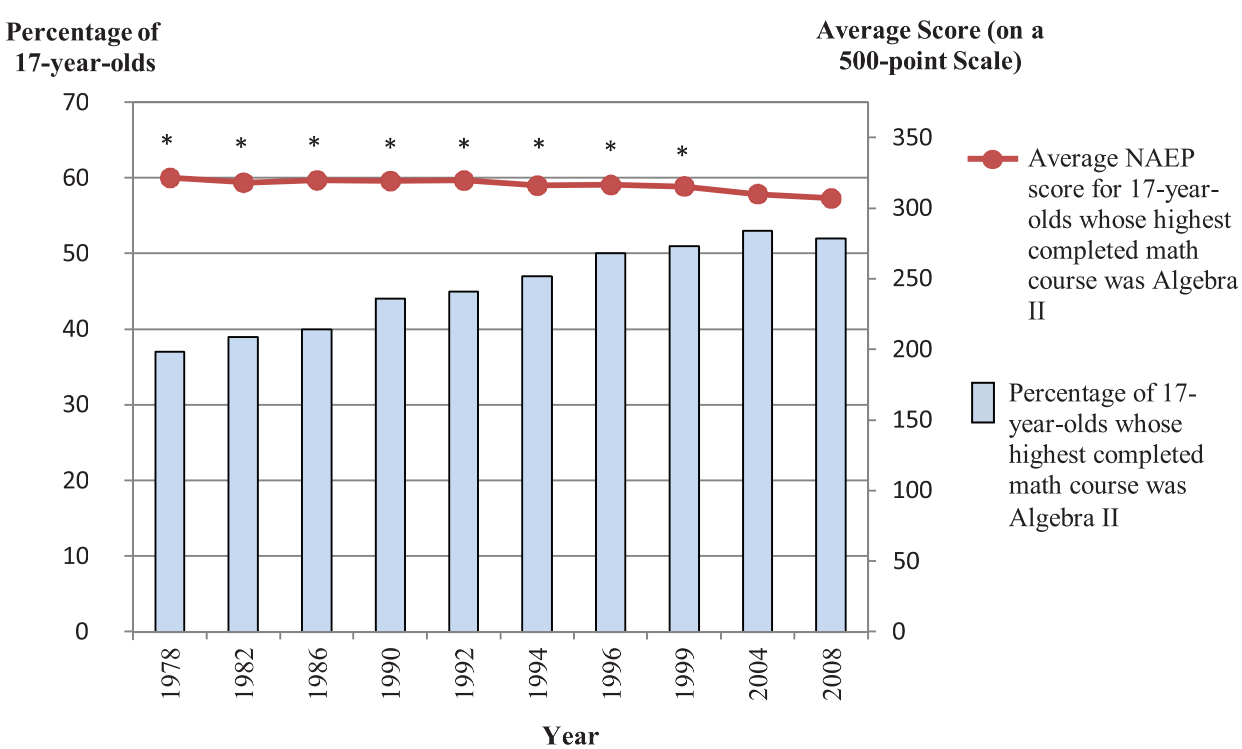
Students currently taking advanced mathematics courses do so voluntarily and usually have stronger mathematics skills. If all students were required to take these courses, they would not necessarily score as high on achievement tests as those currently taking advanced courses voluntarily.

An essential caveat to remember is that high test scores associated with taking advanced mathematics courses reflect some self-selection. Students currently taking these courses do so voluntarily and are usually the students who have strong mathematics skills. If all students were required to take advanced mathematics, the average test scores associated with these courses would be lower. In fact, this phenomenon is evident in the NAEP Long-Term Trend Assessment, a set of exams that are conducted separately from the main set of NAEP exams discussed above. As increasing percentages of students have taken advanced courses, the average NAEP scores associated with those courses have gone down by small but statistically significant amounts. Figure 3.B shows the trends for Algebra II and Figure 3.C shows the trends for Calculus.

As higher percentages of students take Algebra II and Calculus, the high NAEP scores associated with those courses have gone down by small but statistically significant amounts. The courses increasingly represent the full spectrum of student abilities.

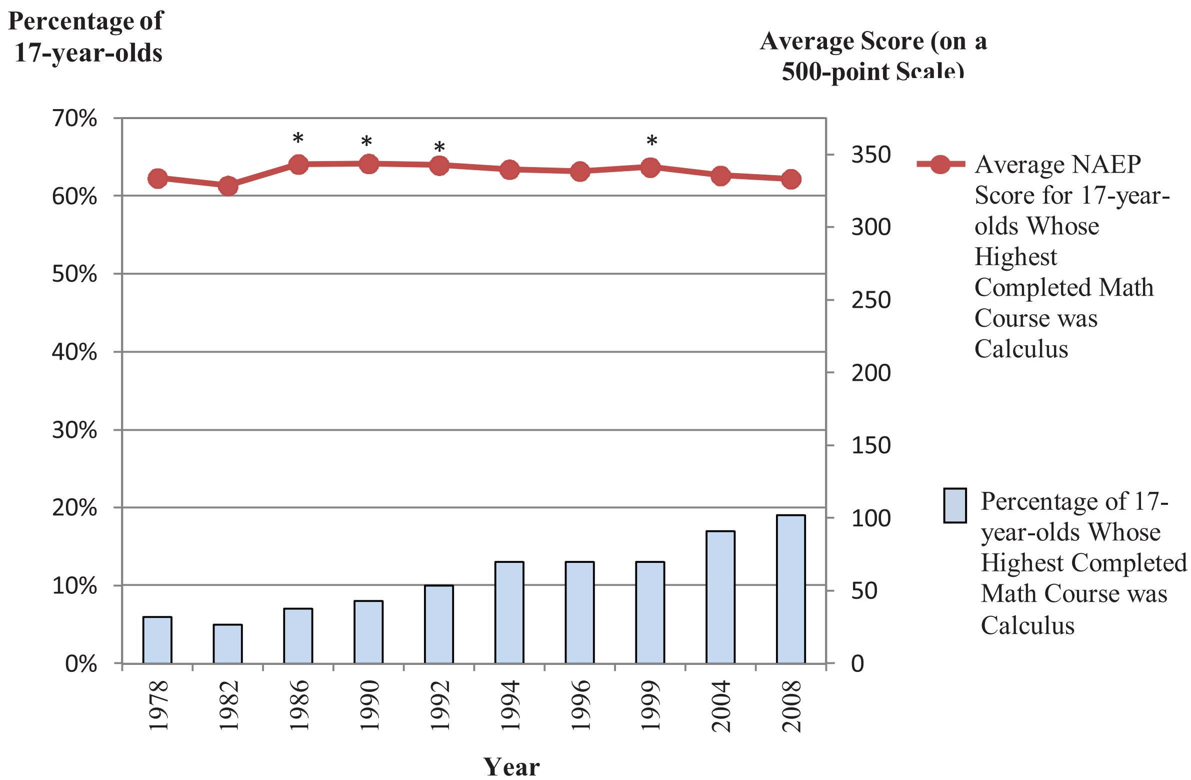
These patterns are due, in large part, to change over time in the types of students taking these courses. When few students take demanding courses, classes tend to be made up of students with the most mathematics ability and motivation. As higher proportions of students start taking these courses, classes will increasingly represent the full spectrum of students. A similar phenomenon occurs with college-readiness exams; a 2007 analysis by OEA found average scores to be highest in states that have the fewest students participating (Commonwealth. Legislative. Office. *Compendium* 57, 63-64). It should be noted that some may interpret these patterns as evidence that advanced courses are less beneficial than they used to be perhaps because courses are being watered down. There are no data to determine the extent to which this may be true.

Figure 3.B
Percentage of 17-year-olds Whose Highest Completed Mathematics Course Was Algebra II and Average Score on NAEP Long-Term Trend Assessment, US, 1978-2008



Note: * indicates scores that were significantly higher than the 2008 score.
Source: US. Dept. of Ed. Inst. Natl. *NAEP Data*.

Figure 3.C
Percentage of 17-year-olds Whose Highest Completed Mathematics Course Was Calculus and Average Score on NAEP Long-Term Trend Assessment, US, 1978-2008

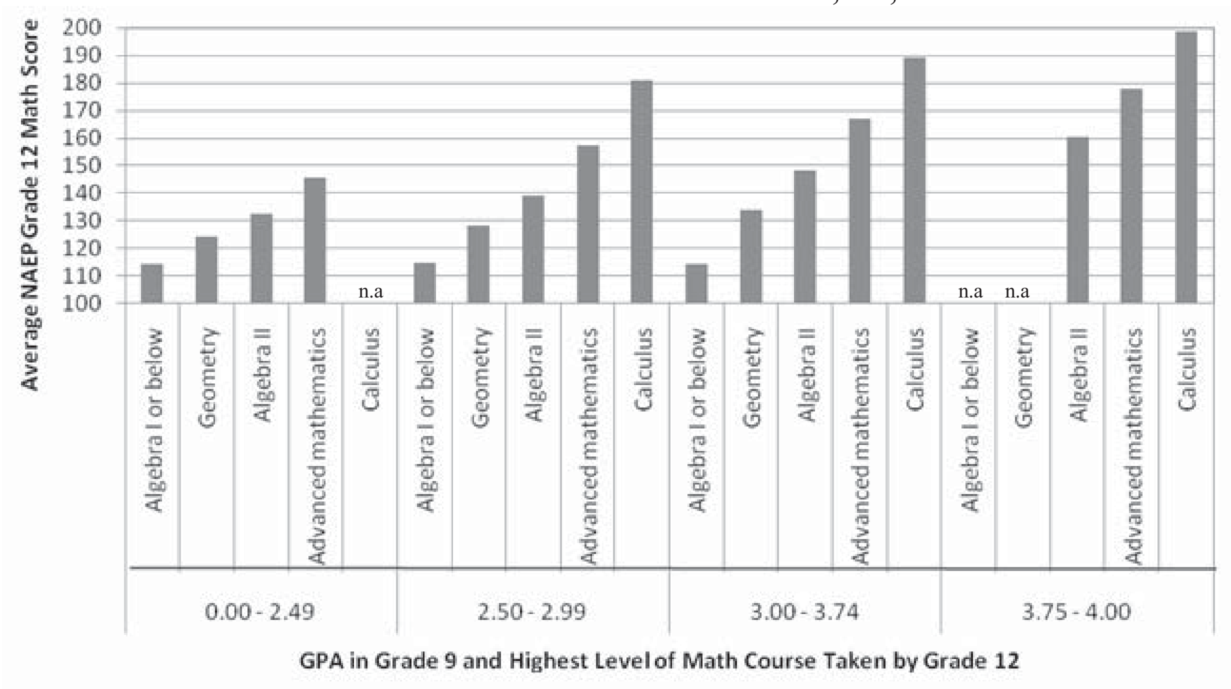


Note: *indicates scores that were significantly higher than the 2008 score.
Source: US. Dept. of Ed. Inst. Natl. *NAEP Data.*

Studies suggest that students in a wide spectrum of ability levels can benefit from demanding math courses. However, students taking the same type of course can have different outcomes. Those with lower achievement levels in grade 9 did not score as high as those with higher achievement levels in grade 9.

Despite these slight declines in scores, studies suggest that students in a wide spectrum of ability levels can benefit from taking more-demanding mathematics courses. The results of one such study is shown in Figure 3.D. Using student transcripts, students were grouped by their grade point average (GPA) in 9th grade and then by the highest mathematics course they had completed by the time they participated in the 12th-grade NAEP mathematics assessment. Those who took more rigorous mathematics courses had higher scores (US. Dept. of Ed. Inst. Natl. *NAEP Data*). Figure 3.D also shows that students taking the same type of course can have different outcomes; students with lower achievement levels in grade 9 did not score as high as those with higher achievement in grade 9.

Figure 3.D
Grade Point Average in 9th Grade, Highest Mathematics Course Completed by 12th Grade, and NAEP Grade 12 Mathematics Scores, US, 2008



Note: Twenty-four percent of students had a grade point average less than 2.50, 23 percent had a GPA between 2.50 and 2.99, 37 percent had a GPA between 3.00 and 3.74, and 16 percent had a GPA of 3.75 or higher.
Source: US. Dept. of Ed. Inst. Natl. *NAEP Data*.

At least some students who are struggling to meet minimum requirements might be better served by taking less-demanding courses in which they would have the ability to master some concepts.

A paradox that should be noted about Figure 3.D is that, among students with the lowest GPAs in 9th grade (lower than 2.5), those who went on to take calculus actually had lower scores than those who took less-advanced courses. This suggests that at least some students who are struggling to meet minimum requirements might be better served by taking less-demanding courses, which would present concepts at a level of difficulty that they could master. Because the lowest category shown in Figure 3.D is quite broad—encompassing GPAs corresponding to F to about a C or C+—it probably masks some differences among students within the category. It might be that students with D or F averages in 9th grade lack the skills to be successful in Precalculus, Algebra II, Geometry, or even Algebra I.

In a national longitudinal study that followed approximately 9,500 high school students for several years, students were tested at the end of grade 10 and again the end of grade 12 using a mathematics test that was vertically scaled—that is, both tests were drawn from the same pool of questions so that gains in proficiency could be accurately measured (US. Dept. of Ed. Inst. Natl. *Mathematics Coursetaking* 27). These gains were analyzed in the context of the mathematics courses that students took in grades 11 and 12. As Table 3.1 shows, students who took more rigorous courses made greater gains.

Initiatives to help struggling students must occur earlier in order to have more substantial impact. The need for strong early foundations in math is a key point made by national authorities on mathematics education. Relying solely on intensive interventions in high school may not be sufficient.

Although the differences were statistically significant, gains for all students were small. Researchers concluded that a substantial amount of the differences among high school graduates could be attributed to factors that predated grades 11 and 12 (US. Dept. of Ed. Inst. Natl. *Mathematics Coursetaking* 27). This finding suggests that policies targeted toward changing the courses students take in grades 11 and 12 will improve proficiency by only small amounts; initiatives must occur earlier in order to have more substantial impact. The need for strong early foundations in mathematics is a key point made by national authorities on mathematics education (Natl. Mathematics; Natl. Council). Relying solely on intensive interventions in high school may be insufficient, as some Chicago high schools found when ACT scores actually dropped as a result of intensive last-minute test preparation (Consortium on Chicago).

Table 3.1
Improvement in Mathematics Performance Between Grade 10 and Grade 12 by Courses Taken in Grades 11 and 12, Educational Longitudinal Study, 2004

Students Who Took This Course in 11th Grade …	And Then Took This Course in 12th Grade …	Had Answered This Percentage of Questions Correctly in 10th Grade …	And Then Answered This Percentage of Questions Correctly in 12th Grade …	Thus, the Percentage Point Improvement for These Students Between 10th and 12th Grade Was:
No math	No math	51%	52%	2%
Geometry	Geometry or no math	48%	52%	4%
Geometry	Algebra II	50%	57%	6%
Algebra II	No math	55%	60%	5%
Algebra II	Trigonometry	58%	68%	10%
Algebra II	Precalculus	63%	71%	9%
Precalculus	No math	68%	74%	6%
Precalculus	Calculus	73%	82%	8%
Precalculus	AP/IB calculus	77%	85%	8%

Source: US. Dept. of Ed. Inst. Natl. *Mathematics Coursetaking* 21.

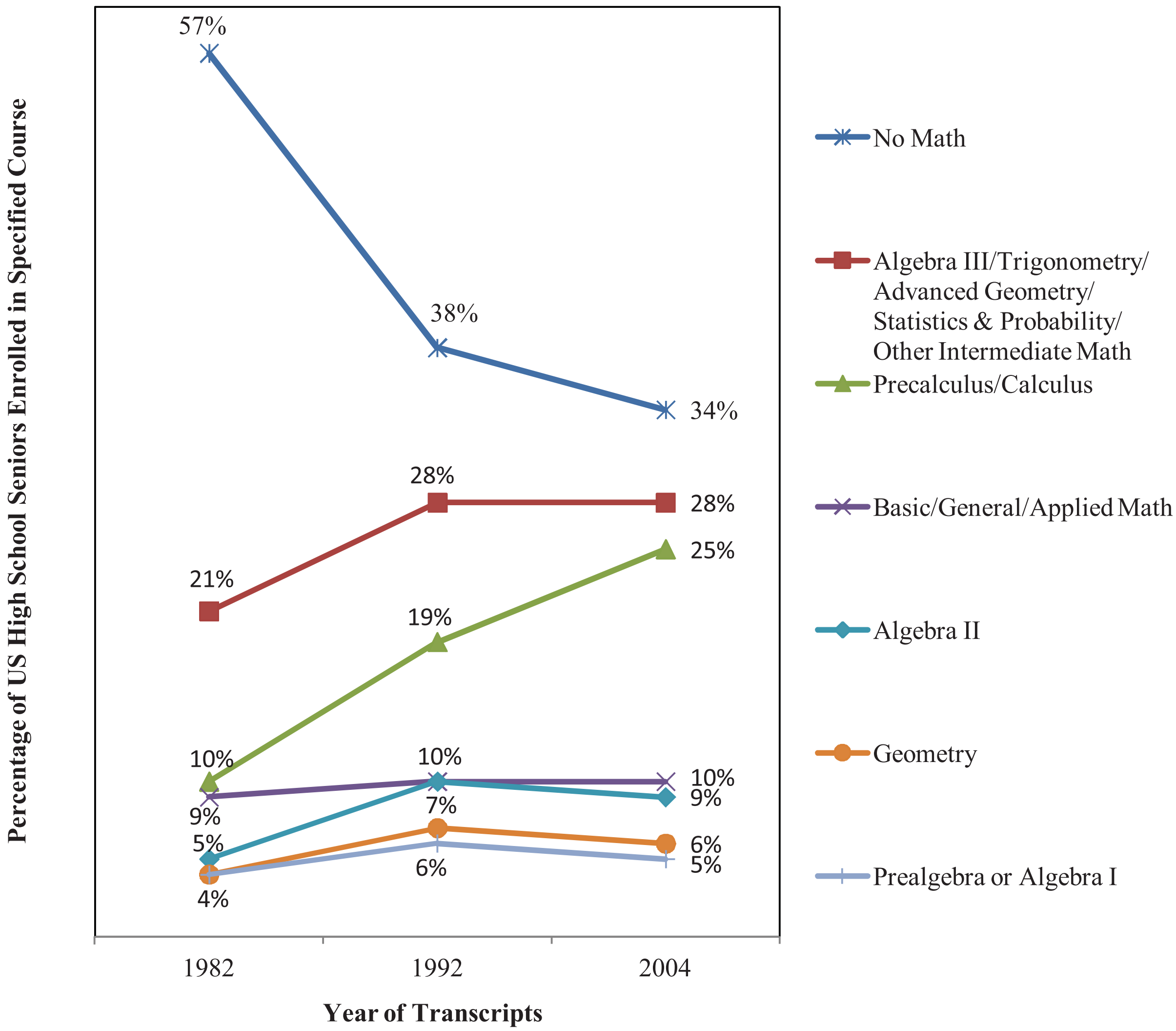
Course Taking

National Course-taking Patterns

Between 1982 and 2004, the number and level of math courses taken by the nation's high school seniors increased substantially. These trends will likely continue, as many states gradually increase math graduation requirements.

An analysis of transcript data from national longitudinal studies revealed a substantial increase between 1982 and 2004 in the number and level of mathematics courses taken by the nation's high school seniors. These trends, shown in Figure 3.E, are projected to continue, as many states gradually increase mathematics graduation requirements (Education Commission).

Figure 3.E
US Trends in Courses Taken by High School Seniors, 1982, 1992, and 2004



Notes: The courses called "Other Intermediate Math" by the National Center for Education Statistics are considered advanced by many researchers and state departments of education. Course percentages add to more than 100 percent because some students were taking more than one type of math course in their senior year.
Source: US. Dept. of Ed. Inst. Natl. *Trends* 6.

Kentucky Course-taking Patterns

An insufficient quantity and quality of course-taking data imposed severe limitations on the analyses that could be conducted for this study.

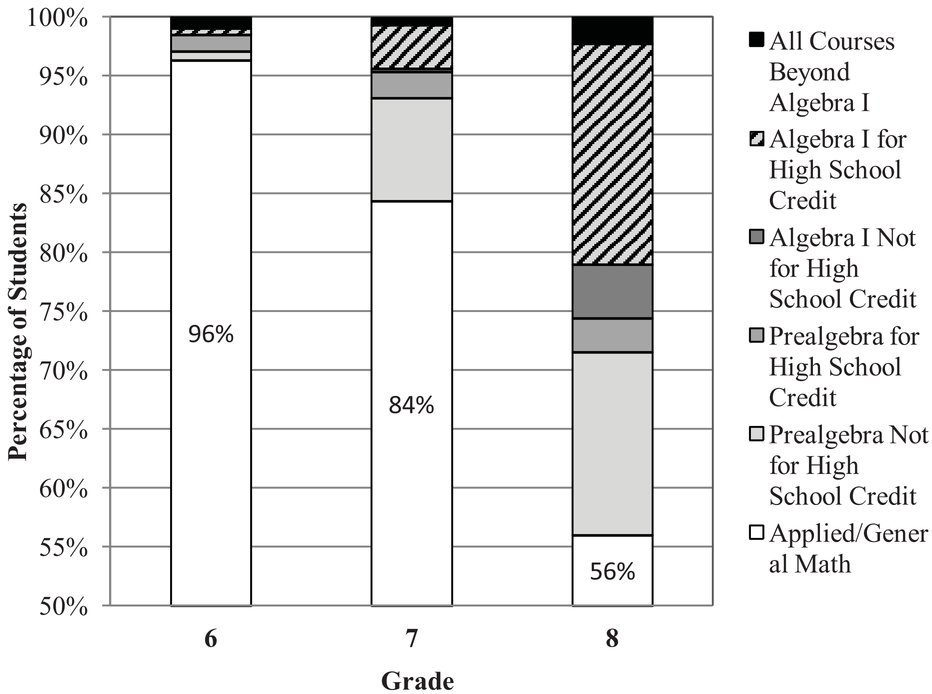
To determine Kentucky's course-taking patterns, staff analyzed course enrollment data from the Student Information System. Due to changes in the Student Information System vendor and other complications, KDE was only able to provide OEA with enrollments for FY 2009. It was not possible to obtain student transcript data to determine the mathematics courses students had taken in previous years; therefore, the analysis provides only a 1-year snapshot of course-taking patterns.

Another important data limitation is that schools and districts do not always assign the correct state codes to courses. This is due, in part, to the fact that districts must type in the codes instead of having a drop-down box from which to choose valid codes; however, districts also need a better detailed understanding of the distinctions among the courses represented by the codes. KDE recently offered training and asked all districts to review and correct course codes, but few participated in the training or corrected course codes. With graduation requirements scheduled to increase for the class of 2012, it is of great concern that inaccurate course codes preclude accurate tracking of the implementation and impact of the new requirements.

The available data show 23 percent of 8th graders taking Algebra I.

Staff analysis of the FY 2009 course data found 23 percent of 8th graders enrolled in Algebra I; 18.7 percent were in schools that had arranged for students to earn high school credit for the algebra course. As Figure 3.F shows, a majority of middle school students were taking general mathematics courses, which are often labeled by grade: Grade 6 Mathematics, Grade 7 Mathematics, or Grade 8 Mathematics.

Figure 3.F
Highest Mathematics Course in Which Middle School Students Were Enrolled by Grade, Kentucky, Fiscal Year 2009



Source: Staff analysis of unpublished data from the Kentucky Department of Education.

Recommendation 3.1

Recommendation 3.1 is that KDE collect student-level data on courses taken, transcripts, and grades; analyze the impact of new graduation requirements; determine if schools are achieving goals; and provide guidance to ensure courses cover expected content with sufficient rigor.

The Kentucky Department of Education should collect student-level data on courses taken, transcripts, and grades. The department should analyze the impact of new graduation requirements, determine whether schools are achieving desired goals, and provide districts with specific guidance and support to ensure that courses cover the expected content with sufficient rigor.

Recommendation 3.2

Recommendation 3.2 is that KDE should ensure that grade-by-grade standards and curricula being developed give students strong early foundations in math so that they will be ready for high school graduation requirements and succeed in assessments.

The Kentucky Department of Education should ensure that the grade-by-grade standards and curricula currently being developed give students strong early foundations in mathematics so that they will be ready to meet the high school graduation requirements and succeed in mandated assessments.

Recommendation 3.3

Recommendation 3.3 is that KDE require all data to be accurate and in compliance. By June 1, 2010, KDE should provide to districts a thorough course code listing with sufficient guidance and content detail. KDE should require districts to use the codes when reporting data starting in the 2011 school year and should annually audit and review the data.

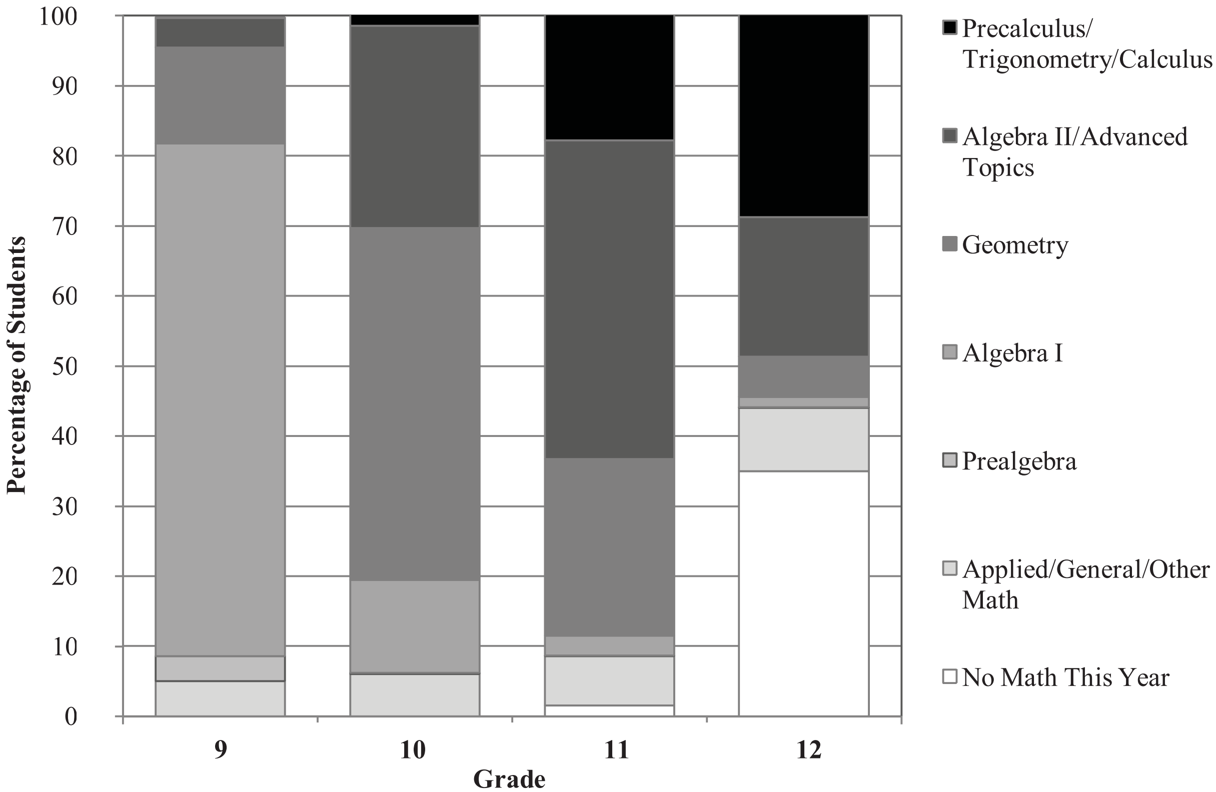
The Kentucky Department of Education should require that all data reported by schools and districts and collected by the department are accurate and compliant with departmental requirements. By June 1, 2010, the department should provide districts with a thorough course code listing with sufficient guidance and detail for the content that should be taught in each course. The department should require that districts use the course codes when reporting data beginning in the 2011 school year and should annually audit and review reported data for compliance.

If the available course-taking data are correct, most high school students already take Algebra II, suggesting that mandating the course starting with the class of 2012 may have little effect on achievement test scores. In 2009, 35 percent of high school seniors took no math. The impending mandate that students take math each year will have a beneficial effect if seniors take math that is of sufficient rigor.

Figure 3.G shows courses taken in Kentucky high schools for FY 2009. Two striking points emerge from this analysis:

- Based on the course codes recorded by schools, it appears that most high school students are already taking Algebra II, including some 29 percent of 10^{th} graders, 46 percent of 11^{th} graders, and 20 percent of 12^{th} graders. If these data are correct, when Algebra II becomes mandatory starting with the class of 2012, it may affect fewer students and have less impact on achievement test scores than expected.
- In 2009, 35 percent of high school seniors took no mathematics at all. This falls within the range of national rates, but it should be cause for concern (US. Dept of Ed. Inst. Natl. *NAEP Data* and *Trends 6*). NAEP data show that students opting out of mathematics in their senior year had taken less-advanced mathematics than other students (US. Dept of Ed. Inst. Natl. *NAEP Data*). Starting with the class of 2012, all Kentucky students will be required to take mathematics in each year of high school. This change will have a beneficial effect if seniors take mathematics that is of equal or greater rigor than the mathematics they have already taken. If, instead, students take less-advanced courses, the change may have little or no impact.

Figure 3.G
Highest Mathematics Course in Which High School Students Were Enrolled, by Grade
Kentucky, Fiscal Year 2009



Source: Staff analysis of unpublished data from the Kentucky Department of Education.

Kentucky Virtual High School

Some math courses were taken online through Kentucky Virtual High School (KVHS), which offers advanced courses and credit recovery for failed courses. KVHS math enrollments represent a fraction of 1 percent of Kentucky's high school students.

Some of the course enrollments in Figures 3.F and 3.G were taken online through Kentucky Virtual High School (KVHS), which offer all students in the Commonwealth an opportunity to take AP courses and other higher-level courses. Another purpose is to offer credit recovery opportunities for students who have failed courses. A recent OEA study noted that total enrollment in all courses was equivalent to about 1 percent of high school students (Commonwealth. Legislative. Office. *Review*).

Table 3.2 shows KVHS enrollments by mathematics course for FY 2008 and FY 2009. The 351 mathematics enrollments in FY 2008 and 498 mathematics enrollments in FY 2009 each represent only a fraction of 1 percent of Kentucky's approximately 196,000 high school students.

In FY 2008, 82 (23 percent) of KVHS mathematics course enrollments were recorded as being for credit recovery so that they could earn credit for the course. Credit recovery enrollments were primarily in Algebra I, Geometry, and Prealgebra.

Table 3.2
Mathematics Course Enrollment Through Kentucky Virtual High School
Fiscal Year 2008 and Fiscal Year 2009

KVHS Course	FY 2008 Number of Enrollments		FY 2009 Number of Enrollments
	Total	Credit Recovery	Total
Business and Consumer Math	23	0	24
Prealgebra	47	14	86
Algebra I	88	40	100
Geometry	81	22	101
Algebra II	35	0	67
Precalculus	19	6	24
Calculus (non-AP)	5	0	8
AP Computer Science	22	0	22
AP Statistics	8	0	19
AP Calculus	23	0	47
Total Number of Enrollments	351	82	498

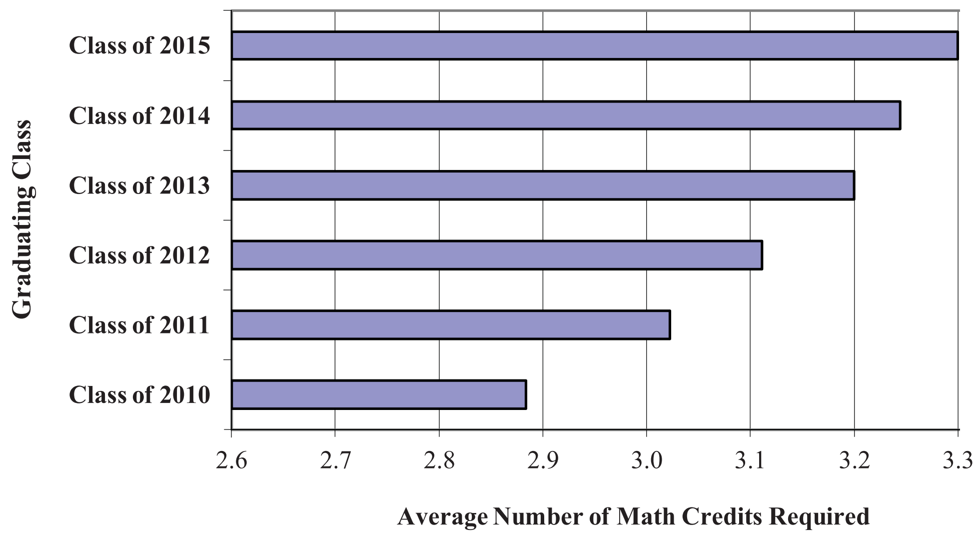
Notes: Credit recovery information is not available for FY 2009. No electronic data are available on Kentucky Virtual High School enrollments for years prior to FY 2008.
Source: Staff compilation of unpublished data from the Kentucky Department of Education.

States' High School Graduation Requirements

Kentucky's class of 2012 must take mathematics in all 4 years of high school but will still be required to earn just 3 credits in that time.

For the graduating class of 2010, most states will require a minimum number of mathematics credits that students must earn in order to graduate. Kentucky requires 3 credits; effective with the class of 2012, students must have taken mathematics in all 4 years of high school but will still be required to earn just 3 credits. Among all states, the average number of credits required in 2010 will be about 2.9. As Figure 3.H shows, most states plan to increase the total number of credits over time, averaging 3.3 credits by the time the class of 2015 graduates (Dounay; Education Commission; websites for all states and the District of Columbia). Appendix F lists graduation requirements for each state and the District of Columbia.

Figure 3.H
Average Number of Mathematics Credits Required by States for Standard High School Diploma

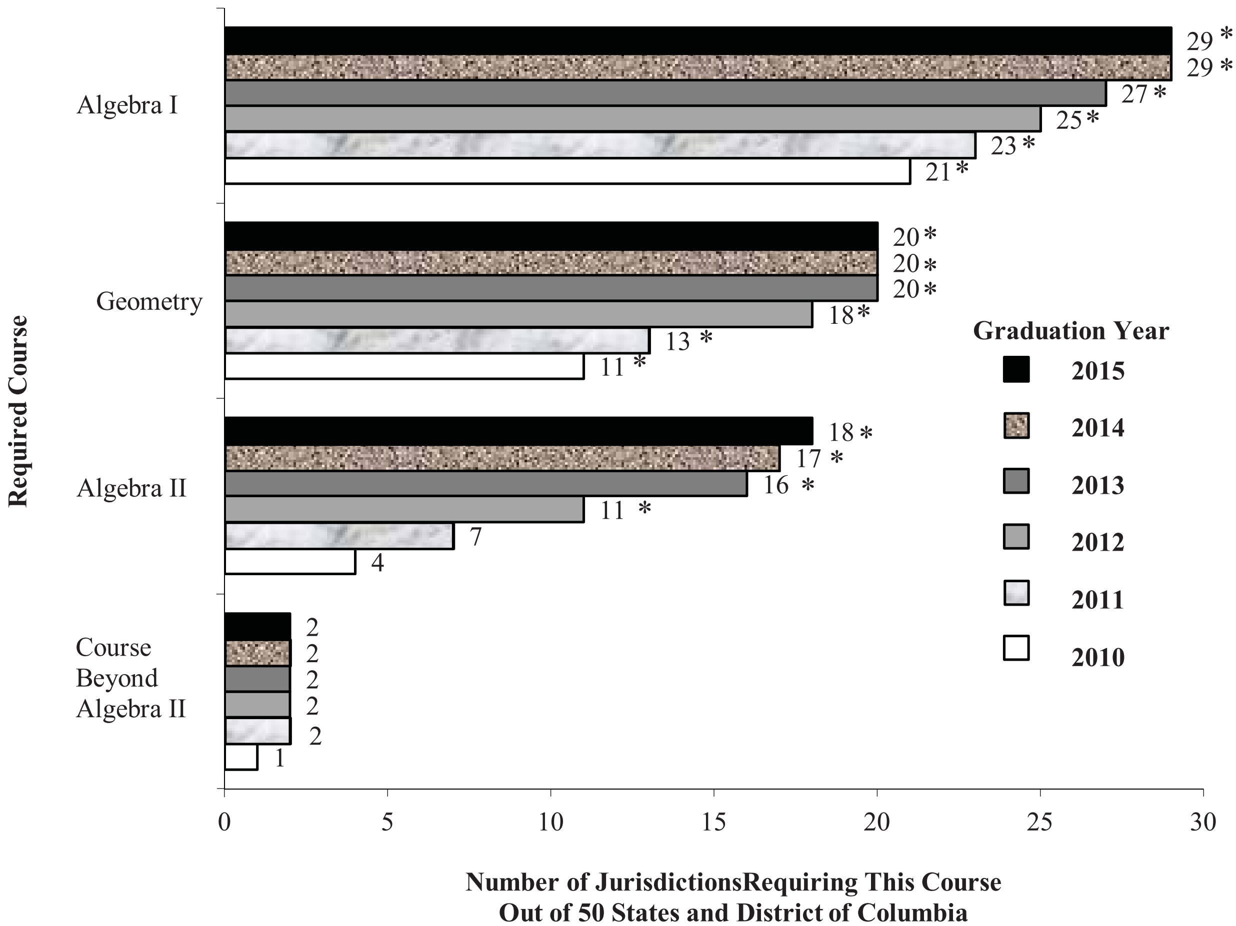


Sources: Dounay; Education Commission; websites for all states and the District of Columbia.

For the class of 2010, 21 states, including Kentucky, require credit for Algebra I. Although only 11 states, including Kentucky, require Geometry in 2010, several plan to add it in the near future. By 2015, Kentucky will be one of 18 states requiring Algebra II. Only Arkansas and Texas plan to require a more-advanced course than Algebra II.

Twenty-one states, including Kentucky, required that students earn credit for Algebra I in order to graduate in 2010. As Figure 3.I shows, by 2015, 29 states plan to require Algebra I. Eleven states, including Kentucky, require Geometry; this number is expected to be 20 by 2015. Kentucky will be one of 18 states requiring Algebra II by 2015. Kentucky's requirement was put in place by means of revisions to 704 KAR 3:305. Only Arkansas and Texas require or plan to require a more-advanced course beyond Algebra II. It should be noted that California and Oregon have delayed changes to graduation requirements because of budget constraints and that other states could change their plans at any time (Dounay).

Figure 3.I
Number of States Planning To Require Specified Courses for High School Graduation Effective Class of 2010 Through Class of 2015



* Years in which Kentucky will require this course.
Sources: Dounay; Education Commission; websites for all states and the District of Columbia.

Some students will struggle to meet new requirements. One solution is to mandate advanced courses but allow students, with parental permission, to opt out and pursue a less demanding curriculum. Some policy makers are concerned that an opt-out approach will be overused and will lead to stigmatizing tracking of students. Kentucky is one of six states that do not allow students to opt out of mandated curriculum.

While striving to set higher expectations for students to reach their full potential, policy makers recognize that some students will struggle to meet the new requirements. Some states address this concern by mandating advanced courses but allowing students, with parental permission, to opt out of the advanced courses and pursue a less demanding curriculum. Proponents of this approach argue that mandating courses leaves too few options for variations among students (Achieve. *Aligning*). However, other policy makers prefer making rigorous courses mandatory for all students out of concern that the opt-out approach will be overused and will lead to a stigmatizing tracking of students. In July 2009, among 19 states that were planning to increase graduation requirements, 13 planned to let students opt out; only 6, including Kentucky, planned to make the requirements mandatory without any opt-out provisions (Achieve. *State* 1).

Beyond the Course Title

A potential unintended consequence of mandatory requirements is that courses might be watered down as students with a wider range of abilities are required to take them. Achieve, Inc. recommends safeguards that are not currently in place in Kentucky.

One unintended consequence of mandatory requirements is that courses might be watered down as more students are required to take them. Achieve, Inc. recommends that states implement safeguards to ensure consistency of course content across the state (Achieve. *Aligning* 10).

Currently, few safeguards are in place to ensure that Kentucky's students receive uniform content for courses with the same title. The content of an Algebra I or Algebra II course can vary from district to district, from school to school within a district, and sometimes from classroom to classroom within a school. The Kentucky Board of Education stated that it has no direct regulatory authority to enforce the use of standardized course codes. Even nonregulatory guidance is scant.

The Kentucky Department of Education last published detailed course design guidelines in 1998. That manual is now out of date and no longer used (Commonwealth. Dept. of Ed. *Implementation*).

The descriptions in the valid list of course codes are brief and general (Commonwealth. Dept. of Ed. *Kentucky Valid*).

Districts and schools are expected to use the Program of Studies as guidance for course content. However, as the high school Program of Studies is not broken out by grade, it provides no guidance on the logical progression of concepts from grades 9 through 12 (Commonwealth. Dept. of Ed. Program).

End-of-course assessments offer one potential solution for ensuring that courses with the same name have the same content. KDE has been engaged in pilots to develop end-of-course exams for Algebra I, Geometry, and Algebra II.

End-of-course assessments offer one potential solution for ensuring that courses with the same name have the same content. On completion of a course, students would take a standardized exam. Results of the test could be compared to state standards and to the performance of other students across the state or even across multiple states. In 2006, the Kentucky General Assembly passed House Bill 197 to establish a pilot program to develop end-of-course exams for Algebra I, Algebra II, and Geometry. KDE has been involved in the two pilots described below.

KDE worked with the University of Louisville Center for Research in Mathematics and Science Teacher Development, teachers, and university faculty across Kentucky to develop end-of-course test items for Algebra I and Geometry. These assessments are aligned with Kentucky's Program of Studies and Core Content for Assessment, as well as with American Diploma Project Benchmarks, ACT benchmarks, and the framework for the 12th-grade NAEP.

A multistate consortium of states' departments of education staff, high school teachers, and university faculty members collaborated to define the content and design of the American Diploma Project Algebra II End-of-Course Exam. Field tests were conducted in October 2007, May 2008, and May 2009. Work continues on refining the assessment items. Work is also under way on an Algebra I end-of-course exam with a design that is parallel to the Algebra II exam (Achieve. *American*).

Student performance on end-of-course pilots has been discouragingly low. There is anecdotal evidence that low student motivation may have been a factor.

Student performance on end-of-course pilots has not been encouraging. In May 2008, selected students in 12 participating states answered 38 percent of the multiple-choice items correctly and earned only 10 percent of the points possible in the open response items[1] The pilots for the Algebra I and Geometry end-of-course exams yielded low scores as well (Achieve. *American*). However, there is anecdotal evidence of low student motivation on the pilots. The Algebra I and Geometry exams were administered during the last week of school, with little preparation, and students had no stake in performing well (Bush).

Recommendation 3.4

Recommendation 3.4 is that KDE evaluate the outcomes of the end-of-course assessment pilots and determine whether these assessments will effectively ensure that all students receive similar content and rigor in comparable courses. If they are proven effective, KDE should inform the Education Assessment and Accountability Review Subcommittee of the outcomes and of the plans and costs associated with statewide implementation.

The Kentucky Department of Education should evaluate the outcomes of the end-of-course pilot initiatives and determine the effectiveness of the tests. The department should determine whether the use of end-of-course assessments is an effective means of ensuring that all students receive similar content and rigor in comparable courses. If such pilot programs prove effective, the department should inform the Education Assessment and Accountability Review Subcommittee of these outcomes and of the plans and costs associated with statewide implementation of such a program for various courses.

[1] Results for Kentucky specifically were 31 and 5 percent, respectively. However, Achieve, Inc. cautioned against reading too much into state comparisons because the number and circumstances of participation varied greatly by state.

Implications of Changing Graduation Requirements

Lessons That Can Be Learned From Other States' Experiences

The experiences of other states when raising graduation requirements point to a need to provide additional student and school support, tailor instruction to different levels of ability, and thoroughly understand the cost implications.

With Kentucky poised to increase graduation requirements for the graduating class of 2012, it would be helpful to learn from others' experiences with such changes in order to maximize the benefits and minimize the negative side effects.

Need for Additional Support. Increasing graduation requirements is most successful at boosting achievement when it is accompanied by student and school support, such as professional development and after school programs. In 1997, Chicago Public Schools mandated that all 9th graders take algebra. As a result, enrollment in algebra increased, but failure rates also increased, test scores did not improve, and students were no more likely to go on to take more-advanced mathematics courses. The district took a number of steps to help students succeed, including the development of curricular materials introducing students to algebraic concepts in grades K-8, requiring struggling 9th graders to take double periods of algebra, providing separate classes for high-ability students, and providing more professional development in mathematics to middle and high school teachers (Viadero). Some initiatives helped to boost standardized test scores, but failure rates remained high (Cavanagh. "'Double Dose'").

Tailoring Instruction to Different Levels of Ability. An analysis of National Education Longitudinal Study data found that having three separate classes for 8th graders with low, medium, and high ability produces the most progress in algebra. For courses other than algebra, the optimum appears to be two levels, one for high-ability students and the other for all other students (Epstein 17-20). Grouping students by ability may raise the specter of stigmatizing by tracking. However, courses need not be explicitly labeled. For example, in Kentucky, Algebra I and Algebra II can each be taught as 2-year courses for students who need extra time; as 1-year courses for students of medium ability; and as accelerated, honors, or college-preparation courses for high-ability students (Commonwealth. Dept. of Ed. *Kentucky Valid*).

An analysis of Kentucky legislation to change graduation requirements anticipated minimal impact on costs. However, there may be additional costs if course content is changed and if there are not enough math teachers for all high school seniors.

Cost Implications. The regulatory impact analysis that accompanied Kentucky legislation to change high school graduation requirements anticipated that the upcoming changes will have minimal impact on costs (Caudill). However, if the content of these courses needs to be changed, there may be costs for new curricula, textbooks, or professional development. The new requirement that students take 4 years of mathematics could also have some impact on costs, unless some staff can be shifted from electives to mathematics.

Other states expect substantial costs for changing graduation requirements, by needing more teachers, classrooms, textbooks, remedial services, state education department personnel, data systems, and other resources.

Other states that have considered implementing new graduation requirements believe such changes could have a substantial impact on costs by needing more teachers, classrooms, textbooks, remedial services, and other resources. Budget constraints recently caused Oregon to delay increased mathematics graduation requirements because schools would need more financial assistance to meet the new goals (Cavanagh. "Higher"). The California legislature's mandate to require 8th graders to take and be tested for Algebra I was blocked by litigation when districts feared they could not afford the added costs of such a change (Cavanagh. "Update").

In 2008, a research and content team conducted a cost analysis of proposed changes to Connecticut's graduation requirements that included increasing the number of credit hours from 20 to 24; requiring more mathematics, world languages, and science courses; and developing a model curriculum for core courses. The analysis identified the following fiscal impacts of these changes:

- Monitoring by the state education department of the courses students take would necessitate one additional information technology staff member ($110,000) and funds to enhance and maintain the statewide student information system.
- Other new state education department personnel would be needed to administer and manage the new programs and initiatives associated with the new graduation requirements. These new personnel would include content specialists in secondary education, middle school education, English language learners, and special education at an estimated cost of $500,000. Clerical staff to meet data and reporting requirements would also be needed.
- The districts that did not already require 24 credit hours for graduation would need to reassign teachers to teach mathematics or hire more teachers. Those districts would also need to hire more guidance counselors to help students with the new requirements. It was noted that the supply of qualified teachers and guidance counselors varied greatly across the state; therefore, some districts would likely have trouble filling the new positions
- A state model curriculum for core high school subjects would cost about $330,000 to develop and implement across a 3-year period. During that same time, teachers would need 5-10 days

of professional development to learn about the new model curriculum.

- The cost analysis looked at end-of-course assessments, which were estimated to cost approximately $10 million to develop and $10 million to $11 million annually to administer and score (Connecticut 9-20).

Increasing high school graduation requirements affects all grades. Students must gain the knowledge and skills in earlier years that will allow them to be successful in Algebra II. Some students might need more than 4 years to fulfill the new requirements.

Implications for Middle and Elementary School Instruction and Curricula. Increasing high school graduation requirements has ramifications for all grades. Students must gain the knowledge and skills in earlier years that will allow them to be successful in Algebra II. Because some students might need more than 4 years to fulfill new requirements for Algebra II, some states plan to require the completion of Algebra I by the end of 8th grade (Education Commission).

Many educators see a need for better math preparation in all grades. The National Mathematics Advisory Panel calls for a more logical progression through foundational math.

In fact, many educators see a need for better mathematics preparation in all grades. The National Mathematics Advisory Panel calls for a more logical progression through foundational mathematics, particularly in whole numbers, fractions, and geometry and measurement, as preparation for algebra. The panel emphasizes the need to provide a rich array of rigorous instruction to help younger students to better understand numbers and perform arithmetic operations. Like language, mathematics requires considerable practice to gain fluency so that students are ready to take on more challenging concepts.

Recommendation 3.5

Recommendation 3.5 is that KDE ensure that program review and outcome evaluation plans are developed, implemented, and reported.

The Kentucky Department of Education should ensure that program review and outcome evaluation plans are developed, carried out, and reported for each initiative to improve student achievement.

Conclusions

Students may not have had many of the early opportunities needed to acquire the knowledge and skills to be successful in math. Strategies and supports will be needed. It will be important to monitor compliance with and the impact of new graduation requirements.

Research suggests that a wide spectrum of Kentucky's students can benefit from taking rigorous mathematics courses, such as the Algebra II course that will soon be a high school graduation requirement. However, some students who are or will soon be in high school may not have had many of the early opportunities needed to acquire the knowledge and skills to be successful. A variety of strategies and supports will be needed, especially for students who are already struggling to pass Algebra I and

Geometry. It will be important to monitor compliance with and the impact of new graduation requirements.

Works Cited

Achieve, Inc. *Aligning High School Graduation Requirements with the Real World: A Road Map for States. Policy Brief.* Washington, DC: Achieve, Dec. 2007. <http://achieve.org/AligningHighSchoolGradRequirements> (accessed Aug. 28, 2009).

---. *American Diploma Project (ADP) End-of-Course Exams: 2009 Annual Report*. Washington, DC: Achieve, Sept. 2009 < http://www.achieve.org/2009ADPAnnualReports> (accessed Sept. 12, 2009).

---. *Closing the Expectations Gap, 2009*. Washington, DC: Achieve, 2009. <http://achieve.org/AligningHighSchoolGradRequirements> (accessed Aug. 28, 2009).

---. *State College- And Work-Ready High School Graduation Requirements*. Washington, DC: Achieve, Jan. 30, 2007. <http://www.achieve.org/files/CourseRequirementsGrid.pdf> (accessed Aug. 28, 2009).

---. *The Expectations Gap: A 50-State Review of High School Graduation Requirements*. Washington, DC: Achieve, 2004. <http://achieve.org/files/coursetaking.pdf> (accessed Aug. 28, 2009).

ACT, Inc. *ACT State Test Profile Report. Spring 2008 ACT-Tested Juniors, Kentucky.* Iowa City: ACT, Inc., 2008. <http://www.education.ky.gov/KDE/Administrative+Resources/Testing+and+Reporting+/Reports/2008+ACT+Tested+Juniors.htm> (accessed May 8, 2009).

---. *Benefits of Additional High School Course Work and Improved Course Performance in Preparing Students for College.* Iowa City: ACT, Inc., Aug. 2008. <http://www.act.org/research/researchers/reports/pdf/ACT_RR2008-1.pdf> (accessed Aug. 12, 2009).

---. "College Readiness and the Impact of Course Rigor." Section III. *2008 ACT National Profile Report*. Iowa City: ACT, Inc., 2008. <http://www.act.org/news/data/08/pdf/three.pdf>(accessed Aug. 12, 2009).

---. "EPAS Educational Planning and Assessment System." Iowa City: ACT, Inc., 2006. <http://www.act.org/epas/index.html> (accessed May 7, 2009).

---. *EXPLORE Profile Summary Report.* Iowa City: ACT, Inc., 2009. <http://www.education.ky.gov/KDE/Administrative+Resources/Testing+and+Reporting+/Reports/EXPLORE+and+PLAN+Data.htm> (accessed May 12, 2009).

---. *PLAN Profile Summary Report.* Iowa City: ACT, Inc., 2009. <http://www.education.ky.gov/KDE/Administrative+Resources/Testing+and+Reporting+/Reports/EXPLORE+and+PLAN+Data.htm> (accessed May 12, 2009).

---. *What Are ACT's College Readiness Benchmarks?* Iowa City: ACT, Inc., 2005. <http://www.act.org/research/policymakers/pdf/benchmarks.pdf> (accessed May 12, 2009).

---. *Your Guide to the ACT*. Iowa City: ACT, 2010. <http://www.act.org/aap/pdf/YourGuidetoACT.pdf> (accessed May 12, 2009).

---. *Your Guide to EXPLORE*. Iowa City: ACT, 2005.

---. *Your Guide to PLAN.* Iowa City: ACT, 2005. <http://www.act.org/plan/pdf/YourGuidetoPLAN.pdf> (accessed May 12, 2009).

American Association for the Advancement of Science. *Science for All Americans*. Washington, DC: AAAS, 1989. <http://www.project2061.org/publications/sfaa/online/sfaatoc.htm> (accessed May 14, 2009).

Barth, Patte. *Score Wars: What to Make of State v. NAEP Tests*. Alexandria, VA: Center for Public Education, National School Boards Association, March 29, 2006. <http://www.centerforpubliceducation.org/Main-Menu/Evaluating-performance/The-proficiency-debate-At-a-glance/Score-wars-What-to-make-of-state-v-NAEP-tests-.GMEditor.html> (accessed Dec. 12, 2009).

Bracey, Gerald. "PISA: Not Leaning Hard on the Economy." *Phi Delta Kappan,* Vol. 90, No. 06 (Feb. 2008): 450-451. <http://www.pdkmembers.org/members_online/publications/Archive/pdf/k0902bra.pdf> (accessed Sept. 25, 2009).

Bush, Bill. Personal interview. Sept. 24, 2009.

Caudill, Emily. "RE: 704 KAR 3:305." Email to Pam Young. Feb. 13, 2009.

Cavanagh, Sean. "'Double Dose' of Algebra Found to Lift Scores, Not Passing Rates." *Education Week. Vol. 28, Issue 29,* April 20, 2009, *8*. <http://www.edweek.org/ew/articles/2009/04/16/29algebra.h28.html> (accessed June 1, 2009).

---. "Higher Math Standards in Oregon Victim of Budget?" *Education Week.* Dec. 15, 2008. <http://blogs.edweek.org/edweek/curriculum/2008/12/math_falls_victim_to_money.html> (accessed Dec. 17, 2008).

---. "Update: California Algebra Ruling Made Final." *Edweek.org Curriculum Matters. De*c. 22, 2008. <http://blogs.edweek.org/edweek/curriculum/2008/12/update_california_algebra_ruli.html > (accessed June 1, 2009).

Cavanagh, Sean, and Kathleen Kennedy Manzo. "International Exams Yield Less-Than-Clear Lessons." *Education Week* April 21, 2009. <http://www.edweek.org/ew/articles/2009/04/22/29nar-assess_ep.h28.html?tkn=XVOF3RKYp9dbLiziaOTN8pESzvWH1sexoJbK&print=1> (accessed Sept. 18, 2009).

College Board. About AP. New York: College Board. <http://www.collegeboard.com/student/testing/ap/about.html> (accessed June 3, 2009).

---. AP Courses and Exams. New York: College Board, 2009. <http://www.collegeboard.com/student/testing/ap/subjects.html> (accessed June 3, 2009).

---. Summary Reports: 2008. New York: College Board, 2009. <http://www.collegeboard.com/student/testing/ap/exgrd_sum/2008.html> (accessed June 3, 2009).

---. *The 5th Annual AP Report to the Nation—Kentucky Supplement*. New York: College Board, 2009. <http://www.collegeboard.com/html/aprtn/pdf/state_reports/09_0467_St_Report_KENTUCKY_X1a_081223.pdf> (accessed June 3, 2009).

Commission on Professionals in Science and Technology. *Skills for the Innovation Economy: What the 21st Century Workforce Needs and How to Provide It*. Washington, DC: CPST, June 2004. <http://www.educationdev.net/edudev/Docs/I2.pdf> (accessed Sept. 8, 2009).

Commonwealth of Kentucky. Council on Postsecondary Education. *Kentucky's Science, Technology, Engineering, Mathematics Imperative: Competing in the Global Economy*. Frankfort: CPE, March 2007. <http://www.cpe.ky.gov/NR/rdonlyres/F42E412A-8508-4269-A50B-1E5F896CD42F/0/STEMreportFINALDRAFTwCovers.pdf> (accessed Sept. 18, 2009).

---. Department of Education. *2006-2007 Technical Report Based on the Analysis of Data from the 2006–07 School Year. Version 1.2.* Frankfort: KDE, Nov. 2008.

---. ---. *CATS Interpretive Guide*. For years 2007 and 2008. Frankfort: KDE. <http://www.education.ky.gov/kde/administrative+resources/testing+and+reporting+/reports/cats+briefing+packets> (accessed May 5, 2009).

---. ---. *Comprehensive Process for the Revision of K–12 to College Entry-Level Course Content Standards: Creating a Focused Teaching and Learning Model to Maximize College and Workforce Readiness*. Frankfort: KDE, April 24, 2009. <http://www.education.ky.gov/KDE/Administrative+Resources/Testing+and+Reporting+/Senate+Bill+1.htm> (accessed Sept. 18, 2009).

---. ---. *Implementation Manual for the Program of Studies: High School*. Frankfort: KDE, 1998. <http://www.education.ky.gov/KDE/Instructional+Resources/Curriculum+Documents+and+Resources/Program+of+Studies/Implementation+Manual+for+the+Program+of+Studies.html> (accessed Aug. 17, 2009).

---. ---. Kentucky Core Content Test Blueprints By Content Area Version 4.1 – Mathematics. Frankfort: KDE, July 21, 2006. <http://www.education.ky.gov/kde/administrative+resources/testing+and+reporting+/kentucky+school+testing+system/accountability+system/blueprint+for+kentucky+core+content+test.htm> (accessed Jan. 8, 2009).

---. ---. Kentucky Education Facts. Frankfort: KDE, June 25, 2009 <http://www.education.ky.gov/KDE/HomePageRepository/News%20Room/Kentucky%20Education%20Facts.htm> (accessed Sept. 8, 2009).

---. ---. *Kentucky Performance Report*. Frankfort: KDE. For fiscal years 2001-2008. <http://applications.kde.state.ky.us/oet/CATSReportsArchive> (accessed May 14, 2009).

---. ---. *Kentucky Valid Course List*. Frankfort: KDE, 2009. <http://www.education.ky.gov/KDE/Instructional+Resources/Curriculum+Documents+and+Resources/Kentucky+Valid+Course+List.htm> (accessed June 3, 2009).

---. ---. Program of Studies—Secondary—High School. Frankfort: KDE, 2006. <http://www.education.ky.gov/users/jwyatt/POS/High.pdf> (accessed June 3, 2009).

---. ---. Qualifying Data based on Free and Reduced Price Information. Frankfort: KDE, 2009. <http://nhs.ky.gov/octdataout/rptlist.htm> (accessed Sept. 30, 2009).

---. Legislative Research Commission. Office of Education Accountability. *A Compendium of State Education Rankings 2008*. Research Report No. 345. Frankfort: LRC, 2007. <http://www.lrc.ky.gov/lrcpubs/RR345.pdf> (accessed Jan. 7, 2010).

---. ---. ---. *Compendium of State Education Rankings 2008*. Research Report No. 362. Frankfort: LRC, 2008. <http://www.lrc.ky.gov/lrcpubs/RR362.pdf> (accessed Jan. 7, 2010).

---. ---. ---. *Indicators of Efficiency and Effectiveness in Elementary and Secondary Education Spending*. Research Report No. 338. Frankfort: LRC, 2007. <http://www.lrc.ky.gov/lrcpubs/RR338.pdf> (accessed Sept. 30, 2009).

---. ---. ---. *Review of Education Technology Initiatives*. Research Report No. 363. Frankfort: LRC, 2009. <http://www.lrc.ky.gov/lrcpubs/RR363.pdf> (accessed Sept. 30, 2009).

Connecticut State Board of Education. Secondary School Reform Cost Analysis. Hartford, CT: Connecticut State Board of Education, 2008. <http://www.edlawcenter.org/ELCPublic/elcnews_090611_ConnecticutCostStudy.pdf> (accessed Sept. 8, 2009).

Consortium on Chicago School Research. *From High School to the Future: ACT Preparation–Too Much, Too Late. Why ACT Scores Are Low in Chicago and What It Means for Schools*. Chicago: Univ. of Chicago, May 2008. <http://ccsr.uchicago.edu/publications/ACTReport08.pdf> (accessed June 1, 2009).

Cook, Philip J., Robert MacCoun, Clara Muschkin, and Jacob Vigdor. *Should Sixth Grade be in Elementary or Middle School? An Analysis of Grade Configuration and Student Behavior*. Durham, NC: Duke Univ., 2007. <http://www.pubpol.duke.edu/research/papers/SAN07-01.pdf> (accessed Sept. 8, 2009).

Council of Chief State School Officers. *Why Isn't the Mathematics We Learned Good Enough for Today's Students? The Imperative of Mathematics Literacy*. Washington, DC: CCSSO, 2005.

Dounay, Jennifer. "RE: State Graduation Requirements – Math." Email to Brenda Landy. March 27, 2009.

Editorial Projects in Education. "Math Stagnation in High School." *Edweek.org.* Live Chat. Aug. 27, 2009. <http://www.edweek.org/ew/events/chats/2009/08/27/index.html> (accessed Aug. 27, 2009).

Education Commission of the States. High School Graduation Requirements: Mathematics. Denver, CO: ECS, March 22, 2007. <http://mb2.ecs.org/reports/Report.aspx?id=900> (accessed May 28, 2009).

Epstein, Joyce L., and Douglas J. MacIver. *Opportunities to Learn: Effects on Eighth Graders of Curriculum Offerings and Instructional Approaches*. Report No. 34. Baltimore, MD: Johns Hopkins Center for Research on Effective Schooling for Disadvantaged Students, July 1992.

Greenspan, Alan. Testimony. Committee on Education and the Workforce. US House of Representatives. March 11, 2004. <http://www.federalreserve.gov/boarddocs/testimony/2004/20040311/default.htm> (accessed Sept. 18, 2009).

Kentucky Center for Mathematics. *Mathematics Intervention Teacher Handbook*. Highland Heights: Northern Kentucky Univ., Aug. 2009 <http://kentuckymathematics.org/intervention/doc/2008/ MIT_Handbook_AUG09.pdf > (accessed May 14, 2009).

LeTendre, Gerald. "International Competitiveness in Science." *Education Week*. June 17, 1998. <http://www.edweek.org/login.html?source=http://www.edweek.org/ew/articles/1998/06/17/ 40letend.h17.html&destination=http://www.edweek.org/ew/articles/1998/06/17/40letend.h17.html&levelId=2100> (accessed Sept. 8, 2009).

Linn, Robert. "Assessments and Accountability." Educational Researcher Vol. 29, No. 2 (Mar. 2000): 4-16.

Linn, Robert, Eva L. Baker, and Stephen B. Dunbar. "Complex, Performance-based Assessment: Expectations and Validation Criteria." *Educational Researcher*, Vol 20, No. 8 (Nov. 1991): 15-21.

National Academy of Sciences. Committee on Science and Public Policy. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: National Academies Press, 2007. <http://www.nap.edu/catalog/11463.html> (accessed May 16, 2008).

National Assessment Governing Board. *Mathematics Framework for the 2007 National Assessment of Educational Progress*. Washington, DC: NAGB, Sept. 2006. <http://nagb.org/publications/frameworks.htm> (accessed Jan. 7, 2010).

National Commission on Excellence in Education. *A Nation at Risk: The Imperative For Educational Reform. An Open Letter to the American People*. Washington, DC: US. Dept. of Ed., April 1983. <http://www.ed.gov/pubs/NatAtRisk/index.html> (accessed May 14, 2009).

National Commission on Mathematics and Science Teaching for the 21st Century. *Before It's Too Late*. Washington, DC: US Dept. of Ed., 2000. <http://www.ed.gov/inits/Math/glenn/toolate-execsum.html#full> (accessed May 14, 2009).

National Council of Teachers of Mathematics. Standards and Focal Points. Reston, VA: NCTM. <http://www.nctm.org/standards/default.aspx?id=58> (accessed March 27, 2009).

National Governors Association, Council of Chief State School Officers, and Achieve, Inc. *Benchmarking for Success: Ensuring US Students Receive a World-Class Education*. Washington, DC: NGA, 2008. <http://www.achieve.org/files/BenchmarkingforSuccess.pdf > (accessed Sept. 25, 2009).

---. Common Cores Standards: Frequently Asked Questions. Washington, DC: Common Core Standards Initiative, 2009. <http://www.corestandards.org/FAQ.htm> (accessed Sept. 25, 2009).

National Mathematics Advisory Panel. *Foundations for Success: Report of the National Mathematics Advisory Panel*. Washington, DC: US Dept. of Ed., March 2008. <http://www.ed.gov/about/bdscomm/list/mathpanel/reports.html> (accessed May 14, 2009).

National Research Council. *Lessons Learned About Testing: Ten Years of Work at the National Research Council*. Washington, DC: National Academies, 2003. <http://www7.nationalacademies.org/dbasse/BOTA_brochure_Lessons_Learned_PDF.pdf> (accessed June 7, 2008).

National Science Foundation. *Science and Engineering Indicators 2008*. Vols. 1 and 2. Arlington, VA: NSF, 2008. <http://www.nsf.gov/statistics/seind08/pdfstart.htm> (accessed Sept. 18, 2009).

Population Reference Bureau. *Population Handbook*. 5th edition. Washington, DC: Population Reference Bureau, 2004. <http://www.prb.org/pdf/PopHandbook_Eng.pdf> (accessed Sept. 14, 2009).

Ramirez, Francisco O., Xiaowei Luo, Evan Schofer, and John W. Meyer. "Student Achievement and National Economic Growth." American Journal of Education Vol. 113 No. 1 (Nov. 2006): 1-29.

Rothstein, Richard. "Lessons: Weighing Students' Skills and Attitudes." *New York Times*. May 16, 2001. <http://www.nytimes.com/2001/05/16/national/16LESS.html> (accessed Sept. 18, 2009).

Standard & Poor's. *The National Assessment of Educational Progress and State Assessments: What Do Differing Student Proficiency Rates Tell Us?* New York: SchoolMatters.com, Fall 2005.

United States. Department of Education. *No Child Left Behind. Standards and Assessment. Non-Regulatory Guidance*. Washington, DC: US DOE, 2003. <http://www.ed.gov/policy/speced/guid/nclb/standassguidance03.pdf> (accessed May 14, 2009).

---.---. Institute of Education Sciences. National Center for Education Statistics. About NAEP. <http://nces.ed.gov/nationsreportcard/aboutnaep.asp > (accessed July 30, 2009).

---. ---. ---. ---. *Answers in the Toolbox: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment*. Washington, DC: NCES, 1999. <www.ed.gov/pubs/Toolbox/toolbox.html> (accessed May 14, 2009).

---. ---. ---. ---. *Mapping 2005 State Proficiency Standards Onto the NAEP Scales*. (NCES 2007-482). US Dept. of Ed. Washington, DC: US DOE, 2007. <http://nces.ed.gov/nationsreportcard/pdf/studies/2007482.pdf> (accessed June 30, 2008).

---. ---. ---. ---. *Mathematics Coursetaking and Achievement at the End of High School: Evidence from the Education Longitudinal Study of 2002 (ELS:2002)*. Statistical Analysis Report. NCES 2008-319. Washington, DC: US DOE, Jan. 2008. <http://nces.ed.gov/pubs2008/2008319.pdf> (accessed May 26, 2009).

---. ---. ---. ---. *NAEP Data Explorer*. Washington, DC: NCES. <http://nces.ed.gov/nationsreportcard/naepdata> (accessed May 14, 2009).

---. ---. ---. ---. NAEP Overview. Washington, DC: NCES. <http://nces.ed.gov/nationsreportcard/about> (accessed July 27, 2009).

---. ---. ---. ---. The NAEP Mathematics Achievement Levels by Grade. Washington, DC: US DOE, Dec. 20, 2006. <http://nces.ed.gov/nationsreportcard/mathematics/achieveall.asp#grade12> (accessed Aug. 12, 2009).

---. ---. ---. ---. *The Nation's Report Card: Mathematics 2007*. (NCES 2007–494). Authors J. Lee, W. Grigg, and G. Dion. Washington, D.C.: US DOE, 2007. <http://nces.ed.gov/nationsreportcard/pdf/main2007/2007494.pdf> (accessed May 14, 2009).

---. ---. ---. ---. *Trends Among High School Seniors 1972-2004*. NCES 2008-230. Washington, DC: US DOE, May 2008. <http://nces.ed.gov/pubs2008/2008320.pdf> (accessed May 26, 2009).

---. ---. ---. ---. *US Performance Across International Assessments of Student Achievement*. Special Supplement to The Condition of Education 2009. Washington, DC: US DOE, Aug. 2009. <http://nces.ed.gov/pubs2009/2009083.pdf> (accessed Sept. 8, 2009).

---. Department of Labor. Bureau of Labor Statistics. BLS Releases 2004-14 Employment Projections. Washington, DC: BLS, Dec. 7, 2005. <http://stats.bls.gov/news.release/archives/ecopro_12072005.pdf> (accessed Sept. 8, 2009).

---. ---. ---. "STEM Occupations." *Occupational Outlook Quarterly*. Spring 2007, 26-33. <www.bls.gov/opub/ooq/2007/spring/art04.pdf> (accessed Sept. 8, 2009).

---. ---. ---. "Tomorrow's Jobs." *Occupational Outlook Handbook*, 2008-09 Edition. Washington, DC: BLS, 2009. <http://stats.bls.gov/oco/pdf/oco2003.pdf> (accessed Sept. 8, 2009).

Viadero, Debra. "Algebra-for-All Policy Found to Raise Rates of Failure in Chicago." *Education Week*. Vol. 28, Issue 24, March 6, 2009, 11. < http://www.edweek.org/ew/articles/2009/03/11/24algebra.h28.html> (accessed June 1, 2009).

Washington Educational Research Association. *Ethical Standards in Testing: Test Preparation and Administration*. University Place, WA: WERA Professional Publications, 1999/revised 2001. <http://www.wera-web.org/pages/publications/WERA_Test_Ethics.pdf> (accessed Aug. 12, 2009).

Way, Walter D. *Precision and Volatility in School Accountability Systems*. Educational Testing Service Research Report RR-06-26. Princeton, NJ: Educational Testing Service, Sept. 2006.

Yecke, Cheri Pearson, and Chester E. Finn. *Mayhem in the Middle: How middle schools have failed America, and how to make them work*. Washington, DC: Thomas B. Fordham Institute, 2005. <http://www.edexcellence.net/doc/2960_MayhemFINAL.pdf> (accessed Sept. 8, 2009).

Appendix A

Kentucky Statutes and Regulations Relevant to This Study as of April 2009

Statutes

Department of Education, Generally

156.018	Role of department with respect to program created by KRS 158.798.

Textbook Commission

156.395	Definition of "instructional materials" for KRS 156.400 to 156.476.
156.400	School subjects' adoption groups—Textbook contracts and purchases.
156.405	State Textbook Commission—Textbook reviewers.
156.407	Selection of textbook reviewers—Review and evaluation process.
156.410	Evaluation of textbooks and programs.
156.415	Conditions to be complied with before textbooks and programs adopted or purchased.
156.420	Bond conditions for person, firm, or corporation offering textbooks.
156.425	Form of statement and bond—Supplemental statement and bond.
156.430	Violation of bond—Suit on bond.
156.433	Instructional materials eligible for purchase with state textbook funds—Review procedure—List of approved materials.
156.435	Adoption of lists—Rejections—Execution of contracts—Publication of lists.
156.437	Administrative regulations for listing, adoption, and purchase of subject programs.
156.439	District allocation for textbook and instructional materials—Use—School plans—Carryover.
156.440	Sample copies of materials selected and placed on state multiple list of recommended textbooks.
156.445	Only recommended textbook or program to be used as basal title—Exceptions—When changes to be effective—Approval of materials for private and parochial schools.
156.460	School official or employee not to act as book agent.
156.465	Reward for adoption of books forbidden.
156.470	Copy of recommended titles to remain in specified office for period of adoption.
156.472	Textbooks for model and practice schools.
156.474	Multiple textbook adoptions.
156.475	Title. [KRS 156.405, 156.474, 157.100, and 157.110 may be cited as "The Rattliff-Ward Textbook Act of 1976."]
156.476	Textbooks for children with impaired vision—Requirement that publisher of adopted textbook furnish American Printing House for the Blind with text in electronic format.

Professional Development for School Personnel

156.551	Definitions for KRS 156.551 to 156.555.
156.553	Teachers' professional growth fund—Purposes—Courses—Duties of Department of Education—Professional development programs—Administrative

regulations—Advancement by local boards of funds to teachers for professional development education—Reimbursement—Priority for use of funds from 2010 to 2016.

156.555 Center for Middle School Academic Achievement—Duties—Location at college or university.

156.557 Standards for improving performance of certified school personnel—Criteria for evaluation—Content of programs—Administrative regulations—Waiver for alternative plan—Appeals—Exemptions—Review of evaluation systems—Assistance to improve evaluation systems.

Education Technology

156.671 Strategic plan for distance learning.

Interagency Commission on Educational and Job Training Coordination

156.740 Interagency Commission on Educational and Job Training Coordination—Membership.

156.745 Purposes—Responsibilities.

156.749 Administrative expenses—Meetings.

Advanced Placement and Dual Enrollment

158.622 Administrative regulations of Kentucky Board of Education relating to advanced placement courses—Duties of Department of Education relating to advanced placement and dual enrollment programs—Credit for Virtual High School and advanced placement courses.

Educational Improvement

158.645 Capacities required of students in public education system.

158.6451 Legislative declaration on goals for Commonwealth's schools—Model curriculum framework.

158.6452 School Curriculum, Assessment, and Accountability Council.

158.6453 Assessment of achievement of goals—Development of Commonwealth Accountability Testing System—Components—High school and college readiness assessments—ACT and WorkKeys—Accommodations for students with disabilities—Assessment design—Biennial plan for validation studies—Local assessment—School report card—Individual student report.

158.6454 National Technical Advisory Panel on Assessment and Accountability.

158.6455 System to identify and reward successful schools—School accountability index—Consequences for schools not meeting goals—Scholastic audits—Formula for school accountability and improvement goal—District accountability—Appeals of performance judgments.

158.6457 Definitions for KRS 158.6452, 158.6453, 158.6455, and 158.6457.

158.6458 Plan for implementation of state assessment and accountability system—Report.

158.6459 Intervention strategies for accelerated learning—Individualized learning plan—Retake of ACT.

158.646 Kentucky Institute for Education Research Board.

158.647 Education Assessment and Accountability Review Subcommittee—Members—Duties—Vote required to act.

158.6471 Meetings—Required attendance for department representative—Report—Assignment of regulation to committee—Consideration.

158.6472 Review of administrative regulations.

158.648 State Advisory Council for Gifted and Talented Education—Purpose—Duties.
158.649 Achievement gaps—Data on student performance—Policy for reviewing academic performance—Biennial targets—Review and revision of consolidated plan.
158.760 School-to-Careers System—Legislative intent—Goals.
158.7603 School-to-Careers Grant Program—Authority for administrative regulations—Advisory committee.
158.798 Program to encourage studies in mathematics, science, and related technologies—Role of Kentucky Science and Technology Council, Inc.
158.799 Name for program created by KRS 158.798.
158.801 Definitions for KRS 158.801 and 158.803.
158.803 Early mathematics testing program—Purposes—Development and requirements of program—Annual reports.

Student Achievement in Mathematics and Reading

158.840 General Assembly findings and intent—Importance of students' reading and mathematics skills in achieving scholastic goals—Roles of statewide entities in improving student achievement.
158.842 Definitions for KRS 158.840 to 158.844—Committee for Mathematics Achievement—Membership, purposes, organization, staffing, and duties of committee—Report to Interim Joint Committee on Education.
158.844 Mathematics achievement fund—Creation—Use and disposition of moneys—Administrative regulations—Requirements for grant applicants—Department to provide information to schools and to make annual report to Interim Joint Committee on Education.

Student Achievement in STEM Disciplines

158.845 Definitions for KRS 158.845 to 158.849.
158.846 Legislative findings concerning academic achievement in STEM disciplines.
158.847 Science and mathematics advancement fund—Purposes—Administrative regulations.
158.848 Grant programs concerning STEM disciplines and AP and IB courses.
158.849 Long-term statewide goals concerning STEM disciplines and AP and IB course participation.

Education Professional Standards Board

161.010 Definitions for KRS 161.020 to 161.120.
161.017 Executive director of Education Professional Standards Board.
161.020 Certificates required of school employees—Filing requirements—Validity and terms for renewal.
161.028 Education Professional Standards Board—Powers and duties regarding the preparation and certification of professional school personnel—Membership.
161.030 Certification authority—Assessments of beginning teachers and teachers seeking additional certification—Conditional certificates—Temporary certificates—Internship—Beginning teacher committee—Resource teachers.
161.032 Certification incentive fund—Purpose of grants—Eligibility—Priorities—Forgivable loan incentive—Stipend—Other financial incentives.
161.048 Alternative certification program—Purpose—Options—Testing and eligibility requirements—Salary schedule.

161.095 Continuing education for teachers.
161.1211 Classification of teachers [ranks I-V].
161.1221 Out-of-field teaching.

Council on Postsecondary Education

164.020 Powers and duties of council.
164.0285 Definitions for KRS 164.0285 to 164.0288.
164.0286 STEM Initiative Task Force—Purpose—Membership—Steering committee oversight and coordination—Administrative attachment—Contracting—Funding.
164.0287 Duties of STEM Initiative Task Force—Strategic plan—Business plan.
164.0288 Kentucky STEM Initiative fund.
164.030 Regulations of council to be followed by state postsecondary educational institutions.
164.525 Center for Mathematics—Creation, duties, and location.

Administrative Regulations

11 KAR 7:010 Incentive Loan Program; mathematics and science.
13 KAR 2:020 Guidelines for admission to the state-supported postsecondary education institutions in Kentucky.
16 KAR 2:120 Emergency certification and out-of-field teaching.
16 KAR 4:050 Dating of certification.
16 KAR 5:020 Standards for admission to educator preparation.
16 KAR 5:050 Master of arts in teaching.
16 KAR 9:050 Alternative training program eligibility requirements for middle school and secondary school teachers.
16 KAR 9:080 University-based alternative certification program.
703 KAR 5:001 Assessment and accountability definitions.
703 KAR 5:010 Writing portfolio procedures.
703 KAR 5:020 The formula for determining school accountability.
703 KAR 5:040 Statewide Assessment and Accountability Program; relating accountability to A1 schools and A2-A6 programs.
703 KAR 5:050 Statewide Assessment and Accountability Program; school building appeal of performance judgments.
703 KAR 5:060 Interim accountability model.
703 KAR 5:070 Procedures for the inclusion of special populations in the state-required assessment and accountability programs.
703 KAR 5:080 Administration Code for Kentucky's Educational Assessment Program.
703 KAR 5:120 Assistance for schools; guidelines for scholastic audit.
703 KAR 5:130 School district accountability.
703 KAR 5:140 Requirements for school and district report cards.
703 KAR 5:160 Commonwealth Accountability Testing System administration procedures.
703 KAR 5:170 Kentucky Highly Skilled Educator Program criteria.
704 KAR 3:303 Required program of studies.
704 KAR 3:305 Minimum requirements for high school graduation.
704 KAR 3:340 Commonwealth Diploma Program.

704 KAR 3:345	Evaluation guidelines.
704 KAR 3:455	Instructional resource adoption process.
704 KAR 3:490	Teachers' Professional Growth Fund.
704 KAR 3:530	Mathematics Achievement Fund.

Appendix B

National Assessment of Education Progress—Additional Information

NAEP Achievement Level Definitions for Grades 4 and 8 Mathematics, 2007

Level	Grade 4	Grade 8
Advanced	(Score of 282 and higher on a 0-to-500 scale) Solve complex nonroutine real-world problems in all areas; display mastery in the use of four-function calculators, rulers, and geometric shapes; draw logical conclusions and justify answers and solution processes by explaining why, as well as how, they were achieved; go beyond the obvious in interpretations and be able to communicate clearly and concisely.	(Score of 333 and higher on a 0-to-500 scale) Probe examples and counterexamples in order to shape generalizations and develop models from these; use number sense and geometric awareness to consider the reasonableness of an answer; use abstract thinking to create unique problem-solving techniques and explain the reasoning processes underlying conclusions.
Proficient	(Score of 249-281) Use whole numbers to estimate, compute, and determine whether results are reasonable; have a conceptual understanding of fractions and decimals; solve real-world problems in all areas; use four-function calculators, rulers, and geometric shapes appropriately; employ such problem-solving strategies as identifying and using appropriate information; organize and present written solutions with supporting information and explanations of how they were achieved.	(Score of 299–332) Conjecture, defend ideas, and give supporting examples; understand connections among fractions, percents, decimals, and other mathematical topics such as algebra and functions; thoroughly understand basic-level arithmetic operations for problem solving in practical situations; be familiar with quantity and spatial relationships in problem solving and reasoning; convey underlying reasoning skills beyond the level of arithmetic; compare and contrast mathematical ideas and generate examples; make inferences from data and graphs, apply properties of informal geometry, and accurately use the tools of technology; understand the process of gathering and organizing data; calculate, evaluate, and communicate results within the domain of statistics and probability.
Basic	(Score of 214-248) Estimate and use basic facts to perform simple computations with whole numbers; show some understanding of fractions and decimals; solve some simple real-world problems in all areas; use—though not always accurately—four-function calculators, rulers, and geometric shapes; have minimal written responses presented without supporting information.	(Score of 262-298) Complete problems correctly with the help of structural prompts such as diagrams, charts, and graphs; solve problems in all areas through the appropriate selection and use of strategies and technological tools, including calculators, computers, and geometric shapes; use fundamental algebraic and informal geometric concepts in problem solving; determine which of the available data are necessary and sufficient for correct solutions and use them in problem solving; have some limited skills in communicating mathematically.
Below Basic	(Corresponds to score below 214) Not defined.	(Corresponds to score below 262) Not defined.

Note: NAEP achievement levels are to be used on a trial basis until officially approved by the US secretary of education.
Source: Staff compilation based on US Dept. of Ed. Inst. Natl. The NAEP Mathematics Achievement.

Appendix C

Kentucky Core Content Test—Additional Information

This appendix provides details regarding the structure and content of the Kentucky Core Content Test (KCCT) in mathematics. Table C.1 summarizes definitions of performance levels that are assigned based on test score ranges, which are shown in Table C.2. Table C.3 shows the percentage of KCCT items dedicated to each mathematics subdomain in each grade. Table C.4 presents KCCT mathematics results by subdomain, section within subdomain, and grade.

Table C.1
KCCT Performance-level Definitions

Distinguished	• Student demonstrates an in-depth, extensive, or comprehensive knowledge of content • Student communication is complex, concise, and sophisticated with thorough support, explicit examples, evaluations, and justifications. • Student uses and consistently implements a variety of appropriate strategies. • Student demonstrates insightful connections and reasoning.
Proficient	• Student demonstrates broad content knowledge and is able to apply it. • Student communication is accurate, clear, and organized with relevant details and evidence. • Student uses appropriate strategies to solve problems and make decisions. • Student demonstrates effective use of critical thinking skills.
Apprentice	• Student demonstrates some basic content knowledge and reasoning ability. • Student communicates reasonably well but draws weak conclusions or only partially solves or describes. • Student attempts appropriate strategies with limited success.
Novice	• Student demonstrates minimal, limited, underdeveloped, and at times inaccurate content knowledge and reasoning. • Student communication is ineffective and lacks detail with no evidence of connections within or between content areas. • Student uses strategies that are inappropriate.

Source: Commonwealth. Dept. of Ed. *CATS Interpretive Guide, 2008* 43.

Table C.2
KCCT Mathematics Score Ranges Corresponding to Each Achievement Level by Grade, Fiscal Year 2007

	Score Ranges by Grade						
Level	**3**	**4**	**5**	**6**	**7**	**8**	**11**
Novice Low	300	400	500	600	700	800	1100
Novice Medium	301-312	401-412	501-512	601-612	701-712	801-812	1101-1112
Novice High	313-319	413-419	513-519	613-619	713-719	813-819	1113-1119
Apprentice Low	320-326	420-426	520-526	620-626	720-726	820-826	1120-1126
Apprentice Medium	327-332	427-432	527-532	627-632	727-732	827-832	1127-1132
Apprentice High	333-339	433-439	533-539	633-639	733-739	833-839	1133-1139
Proficient	340-363	440-463	540-563	640-660	740-761	840-862	1140-1163
Distinguished	364-380	464-480	564-580	661-680	762-780	863-880	1164-1180

Source: Commonwealth. Dept. *CATS Interpretive Guide*, 2007 45 and *CATS Interpretive Guide*, 2008 46.

Table C.3
Blueprint for KCCT Mathematics Assessment, 2007

Subdomain as a Percentage of Test Items	**Percentages by Grade**						
	3	**4**	**5**	**6**	**7**	**8**	**11**
Number Properties and Operations	40	40	40	40	30	22	20
Measurement	10	10	10	10	15	15	12
Geometry	25	20	20	20	20	20	18
Data Analysis and Probability	10	15	15	15	15	15	15
Algebraic Thinking	15	15	15	15	20	28	35

Source: Commonwealth. Dept. of Ed. Kentucky Core.

Table C.4
KCCT Mathematics Results by Subdomain, Section, and Grade, Spring 2008

		Percentage of Items Correct by Grade						
Subdomain	**Section Within Subdomain**	**3**	**4**	**5**	**6**	**7**	**8**	**11**
Number Properties and Operations		67	56	65	51	49	54	45
	Number Sense	81	60	59	75	72	63	n.a.
	Estimation	70	66	75	51	67	77	n.a.
	Number Operations	73	57	68	68	74	60	46
	Ratios and Proportional Reading	n.a.	n.a.	n.a.	49	49	52	42
	Properties of Numbers and Operations	60	45	60	57	53	50	n.a.
Measurement		90	55	48	50	53	55	49
	Measuring Physical Attributes	90	70	73	50	53	54	49
	Systems of Measurement	n.a.	56	44	n.a.	n.a.	74	n.a.
Geometry		75	63	71	60	57	63	55
	Shapes and Relationships	73	64	70	64	50	48	55
	Transformations of Shapes	77	76	80	54	n.a.	69	71
	Coordinate Geometry	n.a.	72	80	61	65	72	43
Data Analysis and Probability		60	61	60	57	61	59	56
	Data Representations	60	59	55	47	75	64	60
	Characteristics of Data Sets	n.a.	n.a.	53	66	54	58	50
	Experiments and Samples	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	67
	Probability	n.a.	65	67	56	63	61	59
Algebraic Thinking		78	70	64	55	58	51	47
	Patterns, Relations, and Functions	76	69	69	59	51	47	34
	Variables, Expressions, and Operations	n.a.	n.a.	50	59	64	57	46
	Equations and Inequalities	77	67	55	52	60	31	48

Note: Percentages were calculated in three steps: 1) The sum of the points earned in open-response items was divided by the total possible points (4 per item). 2) The number of multiple-choice items answered correctly was divided by the total number of multiple-choice items. 3) The quotients from steps 1 and 2 were averaged and then multiplied by 100. For grade 3, this average assigned a weight of 0.33 to the open-response quotient and a weight of 0.67 to the multiple-choice quotient. For all other grades, the quotients had equal weight. The weights in step 3 are in keeping with the formula for determining school accountability (703 KAR 5:020).
Source: Commonwealth. Dept. of Ed. *Kentucky Performance*.

Appendix D

Educational Planning and Assessment System

Table D.1 summarizes the structure and content of Education Planning and Assessment System exams, in terms of time permitted, highest possible scores, total number of test items, and percentage distribution of test items by mathematics subdomain and by cognitive complexity.

Table D.1
Design of Educational Planning and Assessment System Exams

	EXPLORE	PLAN	ACT
Time Permitted (minutes)	30	40	60
Highest Possible Score	25	32	36
Total Number of Test Items	30	40	60
Percentage of Test Items by Subdomain			
Prealgebra/Algebra	63	55	55
Prealgebra	33	35	23
Elementary Algebra	30	20	17
Intermediate Algebra	0	0	15
Statistics/Probability	13	0	0
Geometry	23	45	38
Plane Geometry	23	27	23
Coordinate Geometry	0	18	15
Trigonometry	0	0	7
Total	100	100	100
Percentage of Test Items by Cognitive Complexity			
Knowledge and Skills	27	35	50
Direct Application	27	30	28
Understanding Concepts, Integrating Conceptual Understanding	47	35	22

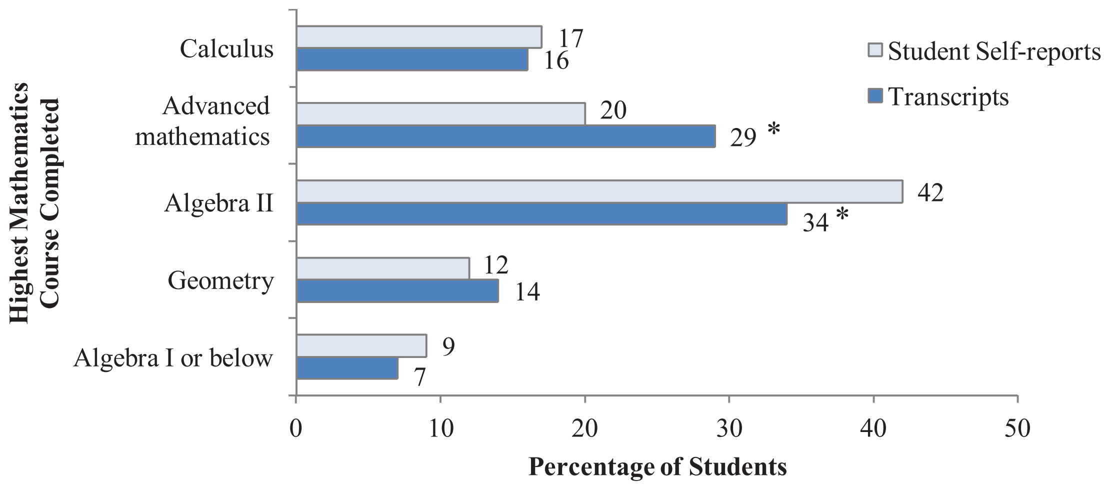
Note: All test items are multiple choice. Totals may round to more or less than 100 due to rounding error.
Sources: ACT. *Your Guide to EXPLORE* 7-9, *Your Guide to PLAN* 7-9, and *Your Guide to the ACT* 7-9.

Appendix E

Course Taking

Figure E.A shows the highest level of mathematics course that 12th graders completed in the NAEP transcript study compared to self-reports of 12th graders at the time they took the NAEP exam.

Figure E.A
Highest Level of Mathematics Course That 12th Graders Completed According to Transcripts and Self-reports, US, 2005



* indicates statistically significant difference between transcripts and students' self-reports.
Source: US Dept. of Ed. Inst. Natl. *NAEP Data* and NAEP Mathematics Achievement.

Table E.1 shows NAEP mathematics scores by the highest mathematics course that the 12th grader had completed at the time of taking the NAEP 12th-grade mathematics exam. Scores are broken out by gender, race, disability status, and English language learner status to show how the relationship between courses taken and test scores varies by student subgroup.

Table E.1
Impact of Math Course Intensity on NAEP Scores, Differences by Subgroup
Grade 12, US, 2005

		Average NAEP Score by Highest Course Completed				
		Algebra I or Below	Geometry	Trigonometry/ Algebra II	Precalculus	Calculus
Gender	Female	115	125	140	163	182
	Male	119	128	145	166	181
Free or Reduced-price Lunch	Eligible	110	119	131	151	154
	Not Eligible	121	129	147	167	186
Race/Ethnicity	Af. Amer./Black	102	110	125	143	150
	Hispanic	107	118	132	153	153
	White	123	134	150	170	187
	Asian	N/A	N/A	144	162	188
Disability	With Disability	100	113	120	N/A	N/A
	No Disability	123	128	144	165	183
Language	ELL	N/A	113	123	N/A	N/A
	Not ELL	119	127	143	165	182

Note: ELL is English Language Learner; N/A indicates insufficient or unreliable data.
Source: Staff compilation of data from US Dept. of Ed. Inst. Natl. *NAEP Data*.

Table E.2 presents the percentages of Kentucky students by the highest mathematics course in which the students are enrolled, by grade.

Table E.2
Percentages of Students by Highest Mathematics Course in Which Students Are Enrolled, by Grade, Kentucky, Fiscal Year 2009

	Middle School Grades			High School Grades			
Course	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Calculus/Precalculus				0.1	1.9	18.4	29.0
Calculus					0.1	1.3	9.5
Precalculus/Algebra with Trigonometry				0.1	1.8	17.2	19.5
Advanced Topics Beyond Algebra II	0.1				0.4	2.0	8.3
Algebra II			0.3	4.2	28.4	43.5	11.6
Topics Beyond Algebra I and Geometry	0.8	0.3	0.4	1.5	2.8	2.5	3.4
Probability and Statistics				0.9	2.6	1.2	2.0
Other	0.8	0.3	0.4	0.6	0.3	1.3	1.4
Geometry		0.3	1.6	13.7	50.3	25.2	5.8
No High School Credit		0.2	0.8				
Algebra I or Below	99.1	99.3	97.8	80.5	16.2	6.7	6.9
Algebra I/Prealgebra	2.7	14.9	41.7	76.7	13.5	2.9	1.6
Algebra I	0.6	3.9	23.3	73.1	13.2	2.8	1.5
No High School Credit		0.3	4.6				
Prealgebra	2.2	11.0	18.4	3.6	0.2	0.1	0.1
No High School Credit	0.7	8.8	15.5				
Integrated Mathematics				1.7	1.6	1.1	0.5
Applied/General Math	96.3	84.3	56.0	2.0	1.2	2.7	4.7
Not Taking Mathematics This Year						1.6	35.0
Total	100	100	100	100	100	100	100

Source: Staff compilation of unpublished data from the Kentucky Department of Education.