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Mathematics Study
Part 3: Achievement in Kentucky Schools, Successful Practices, and Continuing Challenges

Research Report No. 369 Part 3

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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 3 identifies factors associated with high student mathematics achievement and continuing challenges confronting the state as it strives to improve the achievement of all students.

The Office of Education Accountability would like to thank the teachers, school administrators, and district administrators who provided site visit data. OEA would also like to thank staff of the Kentucky Department of Education, the Kentucky Center for Mathematics, the Kentucky Science and Technology Corporation, and the Council on Postsecondary Education for their assistance in completing this report. Finally, OEA would like to thank the researchers, professional development providers, and mathematics consultants who shared their experience working in schools across the state.

Robert Sherman
Director

Legislative Research Commission
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Summary

This report identifies factors associated with high student mathematics achievement in Kentucky schools as well as continuing challenges confronting the state in efforts to improve mathematics achievement for all students. Results are based on Office of Education Accountability site visits to 11 higher- and 6 lower-performing schools; review of state achievement and course-taking data; and interviews with administrators, researchers, and professional development providers.

Site visit schools with higher student mathematics achievement were characterized by strong core mathematics programs that included a well-defined curriculum, curriculum-aligned assessments, staffing and scheduling to meet the range of student needs, and a continuous focus by teachers and administrators on professional learning to improve classroom instruction. These elements were lacking in lower-performing site visit schools.

Site visit data also highlight the critical role of positive, accountable school cultures in promoting high student mathematics achievement. These data reinforce existing studies conducted within the Commonwealth and elsewhere documenting associations between school culture and student performance. Two characteristics of school culture must be understood in mathematics-specific terms. The first is the ability of schools to recruit and retain mathematics teachers capable of meeting the school's high expectations for teacher performance. The second is the ability of administrators to match high expectations for mathematics teaching and learning with instructional support for mathematics teachers.

This report identifies a number of concerns relevant to the General Assembly's goal of reducing the percentage of Kentucky students who require remedial mathematics courses in college. EXPLORE high school readiness tests indicate that many Kentucky students enter high school without the skills necessary to succeed in high school course work; however, site visit and state interview data suggest that many middle and high school students are unlikely to receive the systematic, supplemental support that would be necessary to address weaknesses in their foundational skills. Barriers to providing this type of support include staffing and scheduling challenges as well as lack of knowledge among teachers and administrators about effective remediation strategies for middle and high school students. The Kentucky Department of Education, Council on Postsecondary Education, and Education Professional Standards Board can play a key role in making effective strategies available, but effective supplemental support will ultimately require administrators and school-based decision making councils to make the staffing and scheduling decisions necessary to implement these strategies.

More must be done to ensure that Kentucky students arrive in high school with the foundational skills necessary to succeed. High school teachers and administrators interviewed for this study expressed strong concern about many students' lack of basic skills, especially their automatic recall of basic mathematics facts and their fluency with and conceptual understanding of basic operations, fractions, percents, and decimals. Solutions to this problem will require greater focus on teaching for conceptual understanding through the elementary and middle grades, widespread use of existing diagnostic and intervention resources, and systematic attention to the possible unintended role of calculators in eroding students' ability to compute quickly and accurately. The Kentucky Department of Education, Council on Postsecondary Education, Kentucky Center for

Mathematics, Committee for Mathematics Achievement, and the state's postsecondary institutions can all play a vital role in addressing these issues as they relate to the state's new mathematics standards.

This report also calls for greater attention to accelerated learning for higher-achieving students. State course-taking data indicate wide variation across Kentucky schools in the degree to which middle and high school students have access to challenging course content that will prepare them to be successful by internationally competitive standards. More can be done to focus attention on the needs of these students and to connect schools with existing resources that would assist in development of appropriate course work.

Finally, site visit and state course-taking data highlight concerns about graduation requirements that will apply to the class of 2012. Students graduating in that year must take three math credits that include Algebra I, Geometry, and Algebra II. In addition, students must take one math course each year of high school. However, some district and school administrators are not preparing to meet these requirements. The Kentucky Department of Education can provide crucial guidance to schools in the development of Algebra II and senior-year mathematics courses appropriate for students of various abilities and in the appropriate use of the credit recovery process to assist students who fail mathematics classes. Data also suggest that the new graduation requirements are unlikely to increase students' mathematics achievement in the absence of attention to core elements of mathematics programs.

Recommendations focus on what can be done to scale up successful practices and confront continuing challenges associated with high student mathematics achievement, especially challenges meeting Kentucky's new graduation requirements, and with reducing the number of students needing remedial mathematics classes in college.

Recommendation 4.1
The statute defining school-based decision making councils' responsibilities for curriculum selection lacks clarity. Additional guidance from the Kentucky Department of Education (KDE) would provide schools with more direction and support when selecting and implementing a curriculum.

A. **KDE, in collaboration with the Kentucky Center for Mathematics and the Committee for Mathematics Achievement, should develop definitions of "curriculum" and "needs assessment" as set out in KRS 160.345(2)(i), as they apply to mathematics. The definitions should provide details regarding what is required at the school level when a council is reviewing, identifying, or adopting a mathematics curriculum, including needs assessment, for each elementary or middle school grade level or for each high school mathematics course taught.**
B. **KDE, in collaboration with the Kentucky Center for Mathematics, the Committee for Mathematics Achievement, and other mathematics curriculum specialists in the state, should develop curricular guidelines with regard to the mathematics content and depth of knowledge for each grade level, and where appropriate, for each course. These guidelines should include, at a minimum, the sequence of specific content to be taught, along with guidance on the development of appropriate needs assessments that could be adopted by schools. These curricular guidelines should include grade- and course-level**

modifications to meet the diverse needs of all learners. Guidelines should include links to resources, materials, assessments, and model lessons associated with the specific mathematics content included in the curriculum documents, when available.

C. KDE, in collaboration with the Kentucky Center for Mathematics, Committee for Mathematics Achievement, district mathematics teachers, and university mathematics and education faculty, should develop a consumers' guide to available curriculum materials in mathematics. The guide would provide a review and rating of the materials and should indicate how well the curriculum materials align with the content standards adopted.

D. KDE should provide extensive dissemination of the definitions, curricular guidelines, appropriate instructional practices, and associated materials through training opportunities for school boards, school councils, and other educators to ensure full understanding and use by schools and districts. In addition, the department should promote sharing of curriculum documents and instructional resources from districts and schools that have proven successful in improving mathematics achievement.

E. KDE should develop systematic channels of communication with district and school staff responsible for monitoring and implementing best practices in mathematics teaching and learning.

Recommendation 4.2
The Kentucky Department of Education and the Council on Postsecondary Education should ensure that new standards focus sufficient attention on building students' foundational mathematics skills, including developing conceptual understanding of whole number operations and fractions, decimals, and percents; fluency in the use of number operations; number sense; developing and maintaining automatic recall of basic mathematics facts; and appropriate use of calculators.

Recommendation 4.3
The Kentucky Department of Education, in collaboration with the Council on Postsecondary Education, the Kentucky Center for Mathematics, and the Committee for Mathematics Achievement, should ensure that professional development provided in connection with new standards include specific guidance regarding the use of teaching methods that support development of strong foundations in mathematics. This guidance should include methods related to developing students' conceptual foundations as well as developing and maintaining students' computational fluency. Professional development should include guidance on the appropriate use of calculators and the importance of developing and maintaining automaticity.

Recommendation 4.4
The Kentucky Department of Education, in collaboration with the Kentucky Center for Mathematics and the Committee for Mathematics Achievement, should consider the potential of the new assessment system to identify students who lack the foundational skills necessary to learn grade-level mathematics content. These students should be identified separately in the reporting of annual assessment data to schools. Assessment reports should be accompanied with reference documents that delineate state and other resources that can be used to provide accelerated learning for these students.

Recommendation 4.5
When accurate course code data are available statewide, the Kentucky Department of Education should use the data provided by schools to identify and advise schools and districts that are not providing challenging opportunities for students. Specifically, the department should advise districts and schools when it is determined that Algebra I courses are not available at a middle school and when adequate opportunities for Advanced Placement courses are not available at a high school. The department should provide these schools and districts assistance in developing sufficient opportunities for students in higher-level content courses

Recommendation 4.6
The Kentucky Department of Education should solicit or develop more mathematics-relevant course offerings approved to fulfill the requirements of the Effective Instructional Leadership Act. These courses should use resources currently available in the state, including the Kentucky Center for Mathematics, AdvanceKentucky, postsecondary mathematics and education faculty, and practitioners in the state who have been successful at improving student mathematics achievement.

Recommendation 4.7
By August 2010, the Kentucky Department of Education should require schools to report, through Infinite Campus or other state data-collection systems, those students who have received credit through a credit-recovery course. The department should establish a system to monitor these data and should report by school the percentage of students passing courses by means of credit recovery.

Recommendation 4.8
Before the end of the 2010 school year, the Kentucky Department of Education and the Council on Postsecondary Education (CPE) should provide systematic guidance to educators, administrators, and other school leaders to support implementation of the new graduation requirements. Guidance should include Algebra II course options appropriate for students of different ability levels, as well as 4th-year course options that provide appropriate content for students of different levels. The department and CPE should use current course-taking data to identify and communicate with schools at risk of not meeting the new graduation requirements.

Chapter 1

Overview and Background

Kentucky schools have made steady gains in preparing students to meet state mathematics achievement goals, but progress has been uneven. Some schools have met or are approaching state goals of 100 percent student proficiency. In other schools, math proficiency rates lag 20 or more percentage points below state averages. Challenges are especially great in Kentucky high schools and in schools serving high percentages of students living in poverty.[1]

This study seeks to understand mathematics achievement differences among Kentucky schools.

The goal of this study is to identify factors associated with high student mathematics achievement in some Kentucky schools and challenges confronting the state in promoting high mathematics achievement for all students. This study looked at what accounts for extraordinary performance in higher-performing schools; what is known about the barriers to improving mathematics teaching and learning in others; and how state and local policy makers can increase the use of successful practices and confront continuing challenges.

Results indicate a need for greater focus on the fundamental elements of strong school mathematics programs. These include curricula, staffing and scheduling to meet student needs, and building-level instructional support.

Study results identify key characteristics of strong core math programs, in higher-performing schools. These include clear, well-developed curriculum documents and aligned assessments; staffing and scheduling to meet the specific needs of students spanning the ability spectrum; and ongoing professional learning for teachers that includes mentoring or other forms of building-level instructional support.[2] While these are familiar themes, site visits to lower-performing schools, state interview data, and math program review data suggest that many schools and districts have not focused needed resources and attention on building strong, core mathematics programs.

This study also identifies concerns affecting both higher-and lower-performing schools. These include large numbers of students

[1]Student poverty is most often measured by eligibility for the federal free or reduced-priced lunch program. In this report, references to numbers or percentages of students living in poverty are interchangeable with numbers and percentages of students eligible for the federal free or reduced-priced lunch program.
[2] The term "building-level instructional support" refers to any form of instructional support received by teachers in a school setting. It can include mentoring by administrators or colleagues, opportunities to observe colleagues, or opportunities to meet with colleagues and discuss problems of practice.

entering high school without the foundational skills necessary to benefit from high school course work, regional difficulties attracting and retaining high quality math teachers, and lack of math content training for special education teachers.

Description of This Study

In December 2008, the Education Assessment and Accountability Review Subcommittee directed the Office of Education Accountability (OEA) to study practices used by schools with high student achievement in math.

In December 2008, the Education Assessment and Accountability Review Subcommittee directed the Office of Education Accountability (OEA) to study the practices of schools with high student achievement in mathematics. The study plan included review of specific intervention strategies as well as the broader use of state funds to support math achievement.

How the Study Was Conducted

Findings are based on OEA site visits to 11 higher- and 6 lower-performing schools, interviews with state administrators and professional development providers, and analysis of assessment data.

Findings of this study are based primarily on OEA site visit data consisting of interviews with more than 125 Kentucky administrators and math teachers in 17 schools. The schools were selected because they were performing in mathematics either far higher or far lower than other schools serving students with similar levels of poverty. In addition, staff analyzed Kentucky Department of Education (KDE) course-taking, staffing, and student achievement data. Staff also conducted semistructured interviews with more than 25 state administrators, researchers, and professional development providers with extensive experience working to improve mathematics teaching and learning in the Commonwealth.

Organization of the Report

Chapter 1 provides background, including funding for math programs. It lists statutes and regulations relevant to issues raised in this report.

The remainder of Chapter 1 provides background on the fiscal support for mathematics-specific programs and on statutes and regulations that pertain to concerns raised in this report. The chapter also describes the roles of KDE and other organizations that provide mathematics-specific guidance and support for districts and schools.

Chapter 2 identifies factors associated with success in site visit schools and continuing challenges facing the state, such as many students' weak foundations in math.

Chapter 2 identifies factors associated with high student mathematics achievement in Kentucky schools as well as continuing challenges faced by districts and schools in their efforts to improve mathematics teaching and learning. Data are taken primarily from OEA site visits and interviews with state administrators, university researchers, and professional development providers. The chapter also discusses continuing challenges, such as concerns about many students' weak foundations in math.

Chapter 3 discusses high-school specific issues such as Kentucky's new graduation requirements.

Chapter 3 provides statewide data indicating the degree to which high schools are prepared to meet the new graduation requirements and are currently meeting the needs of struggling and advanced learners.

Chapter 4 summarizes key findings and makes recommendations.

Chapter 4 reviews key concerns raised in the report and makes recommendations about how these concerns might be addressed in the future. It recommends next steps for state leaders responsible for shaping math teaching and learning policies and suggests issues that might be addressed through legislation.

State and Federal Funding for Mathematics Programs

Table 1.1 illustrates major sources of state and federal support for math-specific programs and initiatives in the 2009 fiscal year. Following the table, funded programs are described.

Table 1.1
State and Federal Annual Funding for Mathematics Programs, 2009

Program	Allocation
State	
Mathematics Achievement Fund	$6,900,000
Teachers' Professional Growth Fund*	$347,260
Gatton Academy of Mathematics and Science	$2,716,000
Federal	
Mathematics Science Partnership Grants	$2,677,458
Improving Educator Quality**	$840,000

Notes: * total allocation for the fund was $994,700, of which $347,260 was allocated to the Kentucky Center for Mathematics (Fleming. "Re: KCM 2009"). **A total of $1.2 million was allocated to this fund. The amount reported here was awarded by the Council on Postsecondary Education to math grants.
Sources: State programs from KDE. Mathematics Science Partnership (Kidwell. "Re: MSP"); Improving Educator Quality (DeAtley. "Re: CPE" Oct.).

The Mathematics Achievement Fund supports the Center for Mathematics, renewable 2-year grants to districts, and the Committee for Mathematics Achievement.

Mathematics Achievement Fund

The Mathematics Achievement Fund was established by the General Assembly in 2005 to support initiatives that provide developmentally appropriate diagnostic assessment and intervention services to students in kindergarten through grade 12 (KRS 158.844).

The fund supports the following:

- The Center for Mathematics
- Renewable 2-year local grants to school districts to support the implementation of diagnostic and intervention services in mathematics
- Operational funding for the Committee for Mathematics Achievement

In fiscal year 2009, $1.5 million was allocated to the Council on Postsecondary Education (CPE) for funding of the Kentucky Center for Mathematics (Fleming. "Re: 2007"), and $12,409 was allocated to the Committee for Mathematics Achievement (Rasche). The remainder should have been allocated to fund the 2-year renewable grants to districts. KRS 158.844(7)(f) requires KDE to submit a report to the Interim Joint Committee on Education no later than September 1 of each year outlining the use of the Mathematics Achievement Fund. This report has not yet been submitted for FY 2009.

Kentucky Center for Mathematics

The Center for Mathematics facilitates professional development for teachers in diagnostic assessment and intervention strategies and coaching models.

As described in KRS 164.525, the primary purpose of the Center for Mathematics is to make available professional development for teachers in reliable, research-based, diagnostic assessment and intervention strategies, coaching and mentoring models, and other programs in mathematics. The statute also provides that the center maintain demonstration and training sites at each of the public universities and that it collaborate with Kentucky's public and private postsecondary institutions to develop teachers' mathematical knowledge needed for teaching.

Since 2006, the Kentucky Center for Mathematics (KCM) has facilitated training of 185 intervention teachers and 122 mathematics coaches.

Since 2006, the Center for Mathematics has been located at Northern Kentucky University and has been called the Kentucky Center for Mathematics (KCM). It has facilitated training of 185 mathematics intervention teachers and 122 math coaches; the overwhelming majority of these intervention teachers and coaches work at the elementary level. Among other activities, KCM staff have provided professional development for adult educators;

compiled and posted guidance documents related to curriculum, instruction, and assessment; and obtained a federal grant to increase the number of high-quality math teachers teaching in high-need high schools (Fleming. *Re: KCM Issues*).

Evaluation data show that students receiving interventions progressed at a faster pace than similar students not receiving interventions.

Kentucky Center for Mathematics Evaluation Data. Evaluations of the two main intervention programs for which the center facilitates training and support—Number Worlds and Math Recovery—for the 2007 and 2008 school years show that students who received interventions progressed at a faster pace than similar students who received no interventions.[3] First-grade Math Recovery students in 2007 made gains equivalent to 2.2 grade levels, a full year more than comparison students' scores; gains for Math Recovery students were not as great in all grades and years, however. Number Worlds students in all grades made more moderate but also more consistent gains. The overwhelming majority of Math Intervention Teachers participating in both programs reported positive effects of intervention programs on student learning (Ludwig, Jordan, and Maltbie).

Evaluation data suggest that KCM training develops mathematics intervention teachers' knowledge for teaching and their leadership capacities.

Evaluation data also suggest that KCM training develops mathematics intervention teachers' knowledge for teaching and their leadership capacities beyond what is required to implement the specific intervention programs. Teachers reported substantial shifts, as a result of program participation, in their beliefs, attitudes, and content knowledge (Ludwig, Jordan, and Maltbie 41-50). Math intervention teachers are not specifically trained to be coaches; however, research being conducted at Northern Kentucky University suggests that many have assumed leadership roles in their schools (Fleming. "Re: KCM Issues").

Initial evaluation data raise concerns about the degree to which intervention students' gains are sustained once they leave the program. This concern is currently being addressed by KCM both methodologically in the program evaluation and also in analysis of factors strengthening program implementation (Fleming. "Re: 2007-2008").

Committee for Mathematics Achievement

The Committee for Mathematics Achievement is composed of 26 members that include state agency, postsecondary institution, administrator, and teacher members. Among other duties, it provides advice and guidance to policy makers and reviews research.

The Committee for Mathematics Achievement was created in 2005 by the General Assembly to develop a multifaceted strategic plan

[3] In this report, school years are identified by the last calendar year. Unless otherwise noted, years identified in this report refer to school years. Data for comparison students are not available for 2008. Therefore, intervention students in 2008 are compared to comparison students in 2007.

to improve student achievement in mathematics (KRS 158.842). It is composed of 26 members that include representatives from the KDE, KCM, CPE, Education and Workforce Development Cabinet, Association of Independent Kentucky Colleges or Universities, mathematics educators from the nine Kentucky public postsecondary institutions, adult educators, K-12 teachers, and K-12 administrators. The committee also is charged with other duties that include providing advice and guidance to policy makers and collaborating with KCM to identify research-based intervention programs, coaching and professional development models, and rigorous math curricula.

Teachers' Professional Growth Fund

The Teachers' Professional Growth Fund provides teachers with professional development in content knowledge and teaching methods. In recent years, funds have been allocated to support math coaches and math intervention teachers.

The Teachers' Professional Growth Fund, specified in KRS 156.533, provides teachers with professional development in content knowledge and teaching methods, including assessment and intervention strategies. The Kentucky Board of Education annually determines the priority for content emphasis based on what data indicate are greatest needs. Funds may be used for professional development or continuing education that provide credit toward teachers' certification renewal. The statute also specifies the use of funds beginning June 1, 2006, through the 2010 school year to support training of reading and mathematics coaches and mathematics intervention teachers. Beginning June 1, 2010, through the 2016 school year, funds are to be used to support increases in the number of certified teachers with extensions or endorsement in mathematics and science.

Gatton Academy of Mathematics and Science

The Gatton Academy of Mathematics and Science is a residential program at Western Kentucky University for high-achieving Kentucky 11th and 12th graders.

The Gatton Academy of Mathematics and Science at Western Kentucky University is a residential program for high-achieving Kentucky 11th and 12th graders who are interested in pursuing careers in science, technology, engineering, and mathematics. Sixty students are admitted each year. Students attend university courses with fellow Gatton Academy students and undergraduates, earning a high school diploma and 60 college credit hours by the completion of 12th grade.

Mathematics Science Partnership Grants

Federal Mathematics Science Partnership Grants fund partnerships between high-need school districts, postsecondary faculty, and other partners.

Mathematics Science Partnership grants are funded annually by the federal government through Title II Part B of the No Child Left Behind Act and administered by KDE. Grants fund partnerships between high-need school districts and postsecondary faculty or other partners such as the educational cooperatives described later in this chapter. Examples of projects funded in recent years include teacher-mentor cadres, collaborative curriculum development projects, teacher math alliances, and a collaborative effort to implement the Carnegie Learning Algebra programs and professional development in middle and high schools across the state. According to the grant program administrator, grant activities reveal a need to develop teachers' content and pedagogical knowledge and a need to connect teachers with content, pedagogical, and curriculum specialists who can guide them in developing their skills. Research conducted by the National Science Foundation suggests that professional development activities are more likely to impact teacher practice when they are sustained, develop teachers' content and pedagogical knowledge, and garner administrative support through alignment with district and school goals (Weiss). However, administrators are often reluctant to support these types of sustained and intensive activities (Kidwell. Personal).

Improving Educator Quality Grants

Federal Improving Educator Quality grants fund partnerships between postsecondary institutions and high-need districts. Grants provide professional development for teachers and administrators.

The Improving Educator Quality grant is funded through Title II Part A of the No Child Left Behind Act and is administered by CPE. It awards competitive grants to partnerships that provide research-based professional development for teachers and administrators. Partnerships must include a postsecondary institution's educator preparation program, a postsecondary institution's school of arts and sciences, and at least one high-need local school district. Due to the nature of the projects funded, evaluation data related to student achievement are not available. However, according to CPE, successful funded projects involve collaborative efforts between content and education faculty and include 60 or more hours of professional development for teachers (DeAtley. "Re: CPE" Sept.).

Continuing Grants for Mathematics Programs

In addition to state and federal funds dedicated annually to mathematics initiatives, there are currently many small and several large continuing grants providing resources for additional programs and research opportunities within the Commonwealth. Table 1.2 describes the largest grants.

Table 1.2
Major Continuing Grants for Mathematics Programs

Years of Grant	Grant	Source	Funding in Millions
2003-2010	Appalachian Mathematics and Science Partnership	National Science Foundation	$25.0
2007-2013	AdvanceKentucky	National Mathematics and Science Initiative*	$15.4*
2005-2010	College Bound District Program	General Electric Foundation	$25.0

Notes: This table reports grants exceeding $10 million. Several universities and educational cooperatives have received smaller, externally funded grants. *$13.2 million of the AdvanceKentucky funding is provided through the National Mathematics and Science Initiative; $2 million is funded through an Advanced Placement Incentive Program grant to the Kentucky Department of Education and AdvanceKentucky from the US Department of Education; and $200,000 is funded by the Appalachian Regional Commission.
Source: Appalachian Mathematics and Science Partnership and College Bound District Program funding (Yopp."Re: NSF" Nov. 2 and Nov 3); AdvanceKentucky (Lang).

Appalachian Mathematics and Science Partnership

The federally funded Appalachian Mathematics and Science Partnership supports professional development aimed at building the content and pedagogical knowledge of preservice teachers, classroom teachers, and administrators. Grant activities are developed collaboratively between postsecondary faculty and school districts.

The Appalachian Mathematics and Science Partnership (AMSP) fosters collaborative relationships between postsecondary institutions and school districts with the goal of improving student achievement in math and science. The grant is administered at the University of Kentucky but funds programs at 10 postsecondary institutions in Kentucky, Tennessee, and Virginia. Collaborating institutions in Kentucky, in addition to the University of Kentucky, are Eastern Kentucky University, Kentucky State University, Pikeville College, Union College, Somerset Community College, and the Kentucky Science and Technology Corporation. Thirty-eight central and eastern Kentucky districts have participated in AMSP. Grant activities include professional development aimed at building the content and pedagogical knowledge of preservice teachers, classroom teachers, and administrators.

As is true with professional development programs in general, relationships between program participation and student achievement have been challenging to document. Most AMSP program evaluation data are related to educator perceptions and program implementation. While math scores have been improving in AMSP districts, it is difficult to attribute gains to program participation versus other factors. However, researchers at the University of Kentucky have recently compared AMSP school achievement gains with all Kentucky school gains, attempting to control for multiple variables likely to impact student achievement. This research provides preliminary evidence of small but significant effects of program participation on student achievement in middle and high schools but not elementary schools. Consistent with existing research, the analysis found greater effects for schools with more hours of participation and a higher percentage of teachers participating in the program (Toma and Foster).

AdvanceKentucky

AdvanceKentucky provides schools with grants to increase the number of students enrolling in Advanced Placement (AP) mathematics, science, and English classes; and to increase the number of students attaining qualifying scores on AP exams.

AdvanceKentucky is a partnership between the Kentucky Science and Technology Corporation and the National Mathematics and Science Initiative with the following goals:

- increasing the number of math, science, and English Advanced Placement (AP) courses available to Kentucky students;[4]
- increasing the number of students enrolling in these courses; and
- increasing the number of students taking AP exams and achieving qualifying scores of 3, 4, or 5 on these exams.

The initiative, funded through a grant from the ExxonMobil, Dell, and Gates corporations, provides assistance to schools based on a comprehensive framework developed by the National Mathematics and Science Initiative. The framework includes attention to curricula; recruitment and motivation of students, including those who previously would not have been encouraged to enroll in AP courses; intensive and ongoing content-based professional development for teachers; supplemental instructional time and support for students; instructional resources and supplies; and financial incentives of $100 for each student who achieves a qualifying score on an AP exam as well as $100 for the AP teacher of the qualifying student. From high school grant applicants, 12 Kentucky schools were selected to participate in the first group, which began in the 2009 school year; and 15 schools were selected to participate in the second group, which began in the 2010 school year.

The first group of Kentucky schools receiving AdvanceKentucky grants achieved increases of 61 percent in the number of students taking AP math exams and 84 percent in the number of students earning qualifying scores.

From spring 2008 to spring 2009, schools in the first group increased the number of AP exams taken in math by 61 percent and the number of qualifying scores earned by 84 percent, substantially outperforming the state in exams taken and accounting for all of the gains in exams passed.[5] Schools in the

[4] Eligible AP math courses include Calculus AB, Calculus BC, and Statistics. Additional AP courses covered by the grant include Computer Science A, Biology, Chemistry, Environmental Science, Physics B, Physics C, English Language, and English Literature.
[5] These data differ slightly from those reported by the Kentucky Science and Technology Corporation but show similar trends.

first group also substantially outperformed the state in gains made by minority students and by students eligible for free or reduced-priced lunch.[6] Appendix A contains a list of the first two groups of Kentucky schools that have received grants to participate in the program and data on the performance of these schools in comparison to the state in each subject area.

General Electric College-bound District Program

Through a grant from the General Electric Foundation, Jefferson County has developed standards, common core curricula, ongoing assessments, and intervention for struggling students in math and science.

In 2005, the General Electric Foundation awarded Jefferson County a 4-year, $25 million grant to increase student achievement in math and science and to increase the number of students who are prepared for and attend college. Grant funding has been used primarily to develop rigorous standards, common core curricula in math and science, ongoing assessments aligned with the curricula, computer-based interventions for struggling students, and professional development for teachers. The grant is currently being evaluated by the American Institutes for Research.

Additional Sources of Support

The programs discussed so far provide an infrastructure of support for districts and schools that elect or receive grants to participate in the programs. Additional, though limited, assistance is also available through the Kentucky Department of Education and regional educational cooperatives.

Kentucky Department of Education

The Kentucky Department of Education (KDE) employs three math consultants and one math and science branch manager. Additional programs within the department provide math-specific resources relevant to those programs.

KDE currently has three math consultants and one manager within the math and science branch of the Office of Teaching and Learning. These consultants participate in development of state guidance documents such as the *Characteristics of High Quality Teaching and Learning* (Commonwealth. Department. *Characteristics*). Consultants also serve as liaisons with math networks, assist with the evaluation of Mathematics Science Partnership grants, and collaborate with outside agencies such as the Education Professional Standards Board and CPE in developing valid course codes and addressing college and career readiness issues. Upon request, consultants also provide guidance regarding regulations and resources available to districts and schools. While math consultants are the only KDE staff designated specifically to address issues of math teaching and learning, staff

[6] These percentage gains should be interpreted in light of the fact that many participating schools had very small numbers of minority students.

in multiple programs such as secondary and virtual learning, special education, and assessment also provide assistance relevant to math for those programs.

KDE has also partnered with several postsecondary institutions to develop resources and professional development for administrators and teachers.

KDE has also partnered with several postsecondary institutions in efforts to improve math teaching and learning. For example, the Math Leadership Support Network run by the University of Kentucky's Partnership Institute for Math Science Education Reform, provides state, regional, district, and school leaders with a venue to receive updated information about research, programs, and strategies relevant to improving math teaching and learning. KDE has also partnered with the University of Louisville to develop curriculum frameworks and formative assessments in Algebra I, Geometry, and Algebra II, as well as professional development to support Kentucky high school teachers.

Educational Cooperatives

Kentucky has eight regional educational cooperatives, five of which employ math consultants.

Kentucky has eight regional educational cooperatives, funded by district membership dues, that provide assistance to districts and schools. These cooperatives provide members a range of services that include professional development and support for teachers and administrators. Five have math consultants.

Six of 11 federally funded regional special education cooperatives employ math consultants.

Kentucky also has 11 special education cooperatives that are funded separately by the federal government through the Individuals With Disabilities Education Act. Six have math consultants.

Mathematics support provided to districts and schools varies among cooperatives.

Mathematics professional development and support services vary significantly among the cooperatives. Some, through collaboration with postsecondary institutions or with external funding, have provided sustained support to administrators and teachers. Staff interviews with several cooperative directors indicate challenges in providing mathematics teaching and learning support for member districts. First, some cooperatives have had difficulty recruiting math consultants. Also, cooperatives are limited in the level of support they can provide in the absence of district interest and fiscal support. Several math consultants described difficulties recruiting participants for some of the workshops offered. In other cases, district administrators were reluctant to invest the resources necessary to provide teachers with extended professional development time.

Statutes and Regulations Relevant to Issues Raised in This Report

This report raises concerns related to standards, curriculum, assessment, acceleration, and professional learning. This section summarizes statutory and regulatory guidance in these areas.

New Standards

Kentucky's content standards are being revised to include fewer standards. The standards must be more in depth and work toward helping students gain mastery of the content. The standards must also be aligned from elementary through postsecondary education.

KRS 158.6453(2) mandates that the content standards that specify Kentucky's learning goals be revised by KDE in collaboration with the Council on Postsecondary Education. KDE and CPE are collaborating with the Council of Chief State School Officers and most other states to develop common standards that can be adopted by states. Kentucky work groups composed of teachers, postsecondary faculty, and business and industry representatives are also participating in the development of Kentucky's new standards.

As described in KRS 158.6453(2)(b), new content standards must

1. Focus on critical knowledge, skills; and capacities needed for success in the global economy;
2. Result in fewer but more in-depth standards to facilitate mastery learning;
3. Communicate expectations more clearly and concisely to teachers, parents, students, and citizens;
4. Be based on evidence-based research;
5. Consider international benchmarks; and
6. Ensure that the standards are aligned from elementary to high school to postsecondary education so that students can be successful at each education level.

KRS 158.6453(2)(h) states further that KDE provide or facilitate statewide training related to integrating revised standards into classroom instruction, to integrating performance assessment of students with instructional practices, and to helping students use higher-order thinking and communication skills.

Curriculum Development

The Kentucky Board of Education and KDE set state standards and graduation requirements.

Role of KDE and the Kentucky Board of Education in Curriculum. The broadest guidance for the state's math curriculum is provided by KRS 158.6451(1)(b), which states that:

> schools shall develop their students' ability to use basic communication and mathematics skills for purposes and situations they will encounter throughout their lives.

KRS 158.6451(2) charges the Kentucky Board of Education with disseminating a model curriculum framework that "shall provide direction to local districts and schools as they develop their curriculum." KRS 156.160 directs the board to promulgate regulations establishing standards for the courses of study, common curriculum, and minimum graduation requirements associated with the expected outcomes for students described in KRS 158.6451. The administrative regulation, 704 KAR 3:303, incorporates by reference the "Program of Studies for Kentucky Schools, Grades K-12" that contains the general courses for use in Kentucky schools and requires students to meet the minimum content requirements established in the Program of Studies in order to graduate from high school.

Local boards of education must provide necessary courses and other services. School-based decision making councils must adopt curriculum policies and needs assessments to be implemented by the principal.

Role of School Boards and School Councils in Curriculum. As described in KRS 160.290, local boards of education are given general responsibility to "provide for courses and other services as it deems necessary for the promotion of education" consistent with the general school laws of the state. However, under KRS 160.345, school-based decision making councils are given more specific responsibility for curriculum. KRS 160.345(2)(i) requires the council to "adopt a policy to be implemented by the principal" for the "determination of curriculum, including needs assessment, [and] curriculum development." KRS 160.345(2)(c) states that the council sets school policy that is consistent with board policy and the state's educational goals.

Graduation Requirements

Beginning with the class of 2012, Kentucky high school students will be required to take Algebra I, Geometry, Algebra II, and one math course each year of high school in order to graduate.

Beginning with the graduating class of 2012, Kentucky students must take three math credits that include Algebra I, Geometry, and Algebra II. In addition, students must take one math course each year of high school. Prealgebra may not count as one of the three required credits for graduation but may be counted as an elective (704 KAR 3:305(2)). The regulation goes on to state that a local board of education may substitute alternative courses if they provide rigorous content and address the academic expectations of the statewide assessment program (704 KAR 3:305(3)(1)).

According to KDE, students who receive a mathematics credit through a credit recovery class cannot count that class as a required year of mathematics (Powell).

Assessment

State student assessments must include a criterion-referenced math test in grades 3 through 8, a math high school-readiness exam in grade 8, a math college-readiness exam in grade 10, and the ACT in grade 11. In addition, students must take either a criterion- referenced math test one time within the high school years or end-of-course examinations.

The Kentucky Board of Education is required by KRS 158.6453(3) to create a balanced statewide assessment program based on the revised academic standards and to implement the program in the 2012 school year. The state student assessments may include formative and summative tests that provide teachers and parents a comprehensive analysis of skills mastered by individual students and diagnostic information that identifies strengths and academic deficiencies of individual students (KRS 158.6453(4)(a)). The state student assessments must include a criterion-referenced test in math in grades 3 through 8, a math high school-readiness exam in grade 8, a math college-readiness exam in grade 10, the ACT math exam in grade 11, and a criterion-referenced math test that measures content not included in the ACT to be administered one time in the high school grades. The Kentucky Board of Education may incorporate end-of-course examinations in lieu of the criterion-referenced high school math test (KRS 158.6453(5)).

KDE and the Kentucky Board of Education must assist school districts in developing continuous assessment strategies.

KRS 158.6453(8) states that school districts may select and use commercial interim or formative assessments or develop and use their own formative assessments. KRS 158.6453(18) requires KDE and the Kentucky Board of Education to assist local school districts in developing and using continuous assessment strategies.

Schools enrolling elementary students must use diagnostic assessments to measure math readiness.

Schools enrolling elementary students must use diagnostic assessments to measure math readiness. Schools can use commercially available assessments or develop their own diagnostic procedures (KRS 158,6453(9)).

Additional School Council Responsibilities

School-based decision making councils determine the number of persons employed in each job classification and make scheduling and student assignment decisions. The councils also plan professional development activities.

Under KRS 160.345, school-based decision making councils are given responsibilities related to several issues raised in this report. Section 2(f) of the statute states that the council “shall determine, within the parameters of the total available funds, the number of persons to be employed in each job classification at the school.” Section 2(i) of this statute gives councils the responsibility to adopt curricular policies. Council policies should also include assignment of instructional staff time, assignment of students to classes and programs, and determination of school schedules. Section 8 of this statute requires that school councils plan professional development in compliance with KRS 156.095 and directs that 65 percent of the district's per-pupil state allocation for professional development be allocated to each council.

Accelerated Learning

KRS 158.6453 defines "accelerated learning" as

> an organized way of helping students meet individual academic goals by providing direct instruction to eliminate student performance deficiencies or enable students to move more quickly through course requirements pursuant to higher level skill development.

The statute goes on to require that the results of the state assessment program be used "to determine appropriate instructional modifications for all students in order for students to make continuous progress, including that needed by advanced learners." (KRS 158.6453(5)(f)).

Various statutes require schools to provide accelerated learning opportunities for students with identified strengths or weaknesses. Statutes specify the responsibility of schools to provide these opportunities for students falling below or exceeding expectations.

Various statutes require schools to provide accelerated learning opportunities for struggling and advanced students.
KRS 158.6453(20) (b) requires that a report be given to parents for each student in grades 3 through 8 that summarizes the student's mathematics skills. It further requires staff to develop a plan for accelerated learning for any student with identified deficiencies or strengths. Section 11(b) of the statute requires that students whose scores on the 8th-grade high school readiness exam indicate a high degree of readiness be counseled to enroll in accelerated courses. Students whose scores on the 10th-grade college-readiness exam or on the 11th-grade ACT indicate a high degree of college readiness must be counseled to enroll in accelerated learning courses, with an emphasis on AP classes. KRS 158.6459 requires a student whose scores on the 8th-grade high school readiness exam and the 10th-grade college readiness exam indicate a need for accelerated learning shall have intervention strategies incorporated into his or her learning plan. It also requires that students who do not meet CPE's benchmarks for college readiness on the ACT be provided with accelerated learning opportunities.

The General Assembly has directed the Kentucky Board of Education, CPE, and KDE to develop a plan to reduce college remediation rates.

In the 2009 Regular Session, the General Assembly passed Senate Bill 1 that directs CPE, KDE, and the Kentucky Board of Education to develop a plan to reduce college remediation rates by at least 50 percent from 2010 to 2014.

Professional Development

Four days of the calendar year must be used to provide professional development for building-level staff.

Building-level Professional Staff. KRS 158.070 requires that 4 days of the calendar year be used to provide professional development for building level-professional staff. One professional development day may be used to support districtwide programming at the discretion of the superintendent. The other 3 days are planned by school-based decision making councils. Local boards may also approve flexible programs that allow staff to count professional development attended outside the regular calendar year toward 24 hours of required professional development.

704 KAR 3:035(1) defines "professional development" as:

> those experiences which systematically, over a sustained period of time, enable educators to facilitate the learning of students by acquiring and applying knowledge, understanding, skills, and abilities that address the instructional improvement goals of the school district, the individual school, or the individual professional growth needs of the educator.

The regulation requires districts to develop professional development plans that are implemented and evaluated by a district professional development coordinator. These plans should be aligned with district and school goals as well as teachers' professional growth needs as described in teachers' individual growth plans. School-based decision making councils can also request that district professional development coordinators assist with professional development needs assessments and advise school councils about available professional development opportunities.

School and district administrators must annually complete at least 21 hours of instruction in training approved by the Kentucky Board of Education.

Instructional Leaders. School and district administrators are required by KRS 156.101 to complete no fewer than 21 hours of instruction in training approved by the Kentucky Board of Education. The goal of the training is to develop and maintain administrators' instructional leadership skills. The administering regulation, 704 KAR 3:325, specifies criteria used by KDE to approve programs. Section 3(1)(c) of the regulation requires that training "meet identified needs based upon personnel evaluation, the individual growth plan, and self-assessments of the instructional leaders."

Chapter 2

Supporting Mathematics Achievement: Successful Practices and Continuing Challenges

This chapter identifies factors associated with higher student achievement in mathematics as well as challenges faced by practitioners in ensuring that all students meet state learning goals in mathematics. Findings are based on data collected during OEA school site visits, OEA interviews with mathematics educators and administrators working across the state, and mathematics program audit data collected by independent consultants in Kentucky schools. Methods used to conduct audits are described in Appendix B.

OEA site visit data indicate that higher-performing schools are characterized by accountable, positive school cultures and by strong core mathematics programs that include school or district curricula, aligned assessments, extra support for struggling students, and professional development for teachers that includes building-level instructional support.

OEA site visit data confirm existing research: Successful schools are characterized more by accountable, positive school cultures than they are by specific, replicable practices. However, site visit findings also indicate that higher-performing schools, as a group, share additional mathematics-specific characteristics not evident in lower-performing schools: teachers' use of grade- and course-level curricula to guide planning and assessment, extra support for struggling students, and a focus on professional learning for teachers that includes both external training opportunities and building-level instructional support. These characteristics form the base of what is called a "strong core mathematics program" in site visit schools.

Challenges facing the state include regional shortages in the supply of mathematics teachers, large numbers of students who reach high school without mastering foundational skills, and effective use of special education teachers to teach mathematics.

The chapter ends with discussion of challenges that are relevant to both higher- and lower-performing schools. These include regional shortages in the supply of mathematics teachers, large numbers of students who reach high school without mastering foundational mathematics skills, preparation and use of special education teachers to teach mathematics, and the tendency of district administrators to focus more on reading than on mathematics.

Site Visit Methodology

Differences in Mathematics Proficiency Rates by School Level and Student Poverty

State achievement data provide context for this report's focus on middle schools, high schools, and schools with large percentages of students living in poverty. High schools are, in general, further from meeting proficiency goals than are middle schools. Elementary schools are closest to meeting state proficiency goals. At all levels, the lowest-performing schools are high-poverty schools.

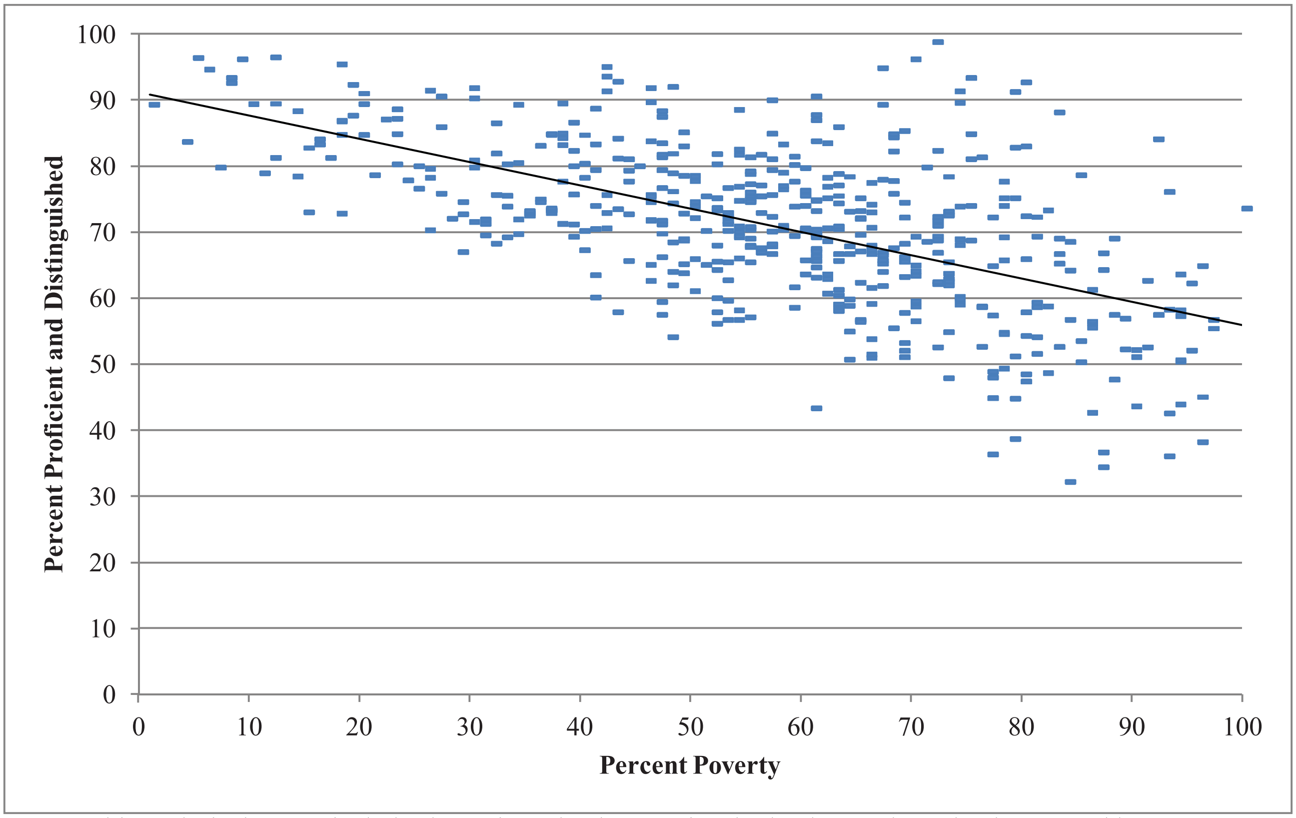
Figures 2A, 2.B, and 2.C present data that provide context for the focus in this report on middle and high schools with higher percentages of students living in poverty. These figures show the percentages of students in elementary, middle, and high schools who achieved scores of proficient or distinguished on the mathematics Kentucky Core Content Test in 2009 relative to the percentage of each school's students eligible for free or reduced-priced lunch.[1] Each point on the plot represents an individual school. High schools are, in general, further from meeting proficiency goals than are middle schools which are, in turn, much further from meeting proficiency goals than are elementary schools.

While there are examples of high-performing, high-poverty elementary and middle schools, there are no such examples of high schools.

These figures show relationships between school poverty and performance at every level. This relationship is especially noticeable in the lower performance ranges; the lowest-performing schools at every level are high-poverty schools. However, there are many examples of high-poverty elementary schools and some examples of high-poverty middle schools that perform as well or better than their lower-poverty peers. Notably, there are no such examples at the high school level.

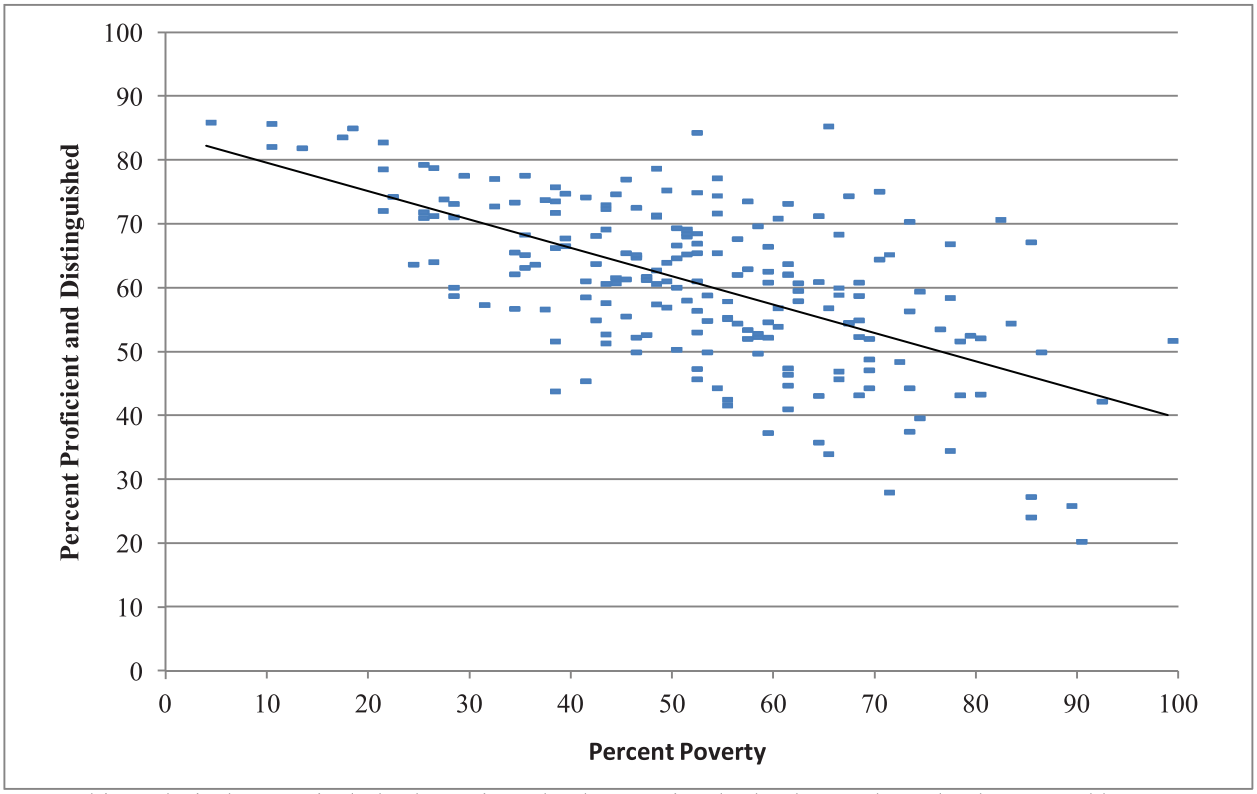
[1] Site visit schools were chosen based on 2008 Kentucky Core Content Test and student poverty data. The 2009 KCCT data provided here show similar trends.

Figure 2.A
Mathematics Kentucky Core Content Test Elementary School Percent Proficient and Distinguished and Student Poverty by School, 2009



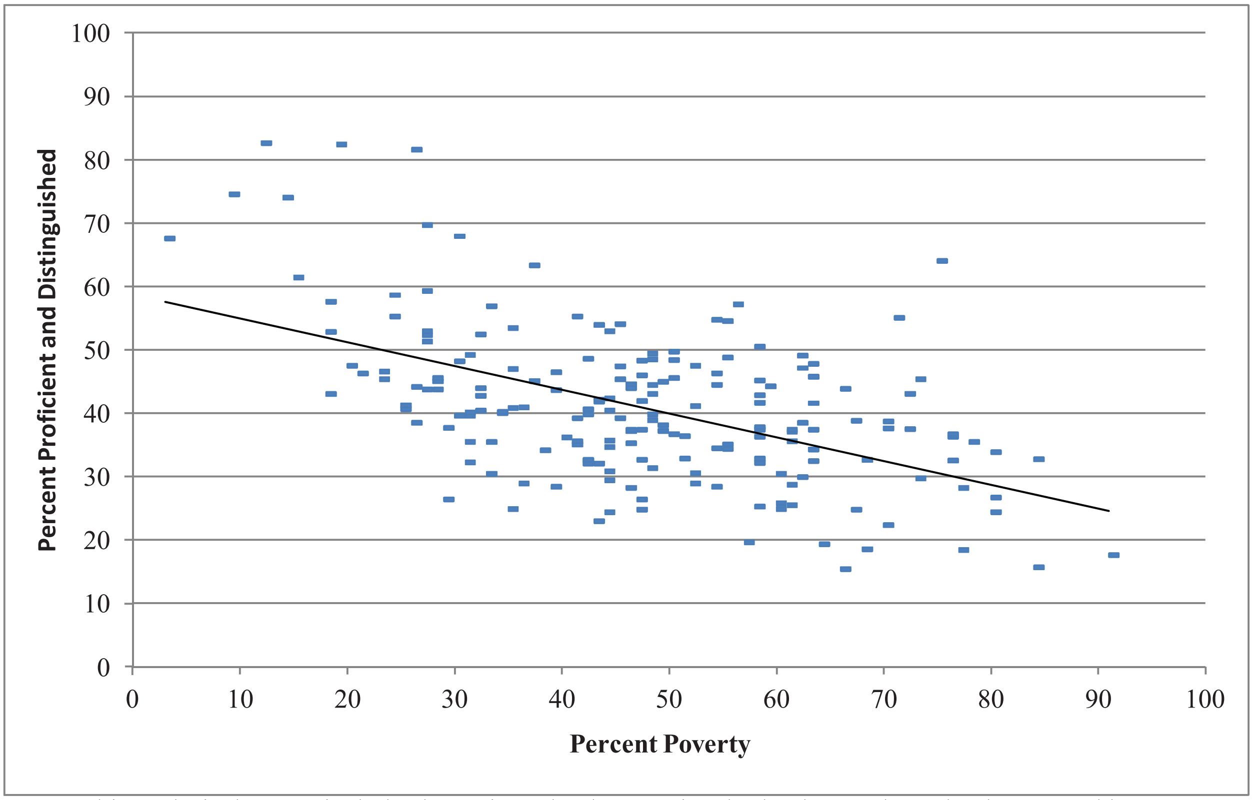
Note: This analysis does not include alternative schools, vocational schools, or other schools operated by or as a part of another school. The correlation coefficient for percent proficient and distinguished and percent student poverty, by school, at the elementary level was -0.58.
Source: Staff analysis of 2009 KCCT mathematics and 2008 student poverty data from the Kentucky Department of Education.

Figure 2.B
Mathematics Kentucky Core Content Test Middle School
Percent Proficient and Distinguished and Student Poverty
by School, 2009



Note: This analysis does not include alternative schools, vocational schools, or other schools operated by or as a part of another school. The correlation coefficient for percent proficient and distinguished and percent student poverty, by school, at the middle school level was -0.61.
Source: Staff analysis of 2009 KCCT mathematics and 2008 student poverty data from the Kentucky Department of Education.

Figure 2.C
Mathematics Kentucky Core Content Test High School Percent Proficient and Distinguished and Student Poverty by School, 2009



Note: This analysis does not include alternative schools, vocational schools, or other schools operated by or as a part of another school. The correlation coefficient for percent proficient and distinguished and percent student poverty, by school, at the high school level was -0.53.
Source: Staff analysis of 2009 KCCT mathematics and 2008 student poverty data from the Kentucky Department of Education.

Sample

OEA visited 11 higher- and 6 lower-performing schools. Higher-performing schools are relatively closer to state proficiency goals than other schools with similar percentages of students living in poverty.

OEA chose a sample of 17 site visit schools weighted in favor of high schools and middle schools with far higher or lower KCCT mathematics achievement than other schools with similar percentages of students living in poverty. Of 17 site visit schools, 5 were higher-performing high schools, 4 were higher-performing middle schools, and 2 were higher-performing elementary schools. Higher-performing elementary schools were much closer to the goal of 100 percent student proficiency than were higher-performing middle and high schools. To allow for contrast, the sample also included 3 lower-performing high schools, 2 lower-performing middle schools, and 1 lower-performing elementary school. The term "consistently higher-performing" high school refers to the three higher-performing high schools with high student achievement on multiple achievement measures. Appendix C describes the methods used to choose site visit schools and includes performance and student poverty data for site visit schools.

Data

Site visit data comprise primarily interviews with mathematics teachers, principals, and district administrators.

Site visit data comprise primarily structured interviews with mathematics teachers, special education teachers responsible for teaching mathematics, principals, and other administrators. OEA also interviewed superintendents and other district administrators in each site visit school district. Staff interviewed 29 school administrators, 48 district administrators, and 75 teachers. Appendix D contains the site visit interview protocols.

Staff also analyzed mathematics achievement data, consolidated plans, personnel evaluations, individual growth plans, and other documents.

OEA staff analyzed all site visit school mathematics achievement data, school and district consolidated plans, and other documents related to mathematics teaching and learning such as teacher/administrator evaluations, teacher individual professional growth plans, curricula, assessments, best practices documents, and professional development agendas.

Limitations

OEA site visit data are limited by the small number of schools visited, by the lack of classroom-level data, and by the lack of observations over time. Findings are not necessarily generalizable across the state.

OEA site visit data are limited by the small sample of elementary, middle, and high schools visited and by the lack of classroom-level data. It is not possible to know how many of the site visit findings for higher- and lower-performing schools apply to other schools with similar characteristics across the state. Where possible, site visit findings are supported with additional state-specific data.

Site visit data are focused on school-level characteristics and do not include classroom observations or other data that provide indicators of instructional quality. Finally, school-level data were derived from the comments and opinions of teachers and administrators in individual interviews.

Summary of Site Visit Findings

Higher-performing site visit schools were characterized by positive, accountable cultures; teachers' use of curricula and aligned assessments; staffing and scheduling to meet the needs of individual students; building-level instructional support; and feeder school student populations with above average mathematics achievement. These characteristics were lacking in lower-performing schools.

Table 2.1 describes mathematics-specific characteristics of higher-performing site visit schools in the areas of culture, curriculum, acceleration, professional development, and performance of students entering the school. School, teacher, and administrator characteristics described in this table and in the report refer only to mathematics programs unless otherwise noted. The shaded rows of the table highlight characteristics of greatest contrast between higher- and lower- performing schools: group accountability, use of district or school curricula for lesson planning, use of curriculum-aligned assessments, extra support for struggling students, building-level instructional support, and above average performance of students entering from feeder schools. These characteristics were identified in all or almost all higher-performing schools and few or no lower-performing schools. OEA interviews with state administrators and mathematics educators suggest that these characteristics are lacking in many schools across the state. Further, Mathematics Program Improvement Profile data reported in Appendix B indicate only moderate or less-than-moderate consistency with best practices in mathematics curriculum, assessment, support for struggling students, and leadership in 32 Kentucky schools. Consultants report similar concerns from observations in many more Kentucky schools.

The table also describes characteristics such as positive school climates, Commonwealth Accountability Testing System data analysis, and teachers' regular attendance at mathematics conferences or workshops that were common in both higher- and lower-performing schools. While these characteristics were cited as contributing factors in the success of higher-performing schools, they appeared to have less impact in schools with other program weaknesses.

Finally, the table highlights contrasts in the performance of students entering site visit schools. Almost all higher-performing site visit schools benefited from feeder school populations that were already performing above state averages, whereas lower-performing schools received students who were already performing below state averages.

Table 2.1
Characteristics of Higher- and Lower-performing OEA Site Visit Schools
Practices Reported for the 2008 School Year

Characteristic	Frequency: Higher-performing Schools	Frequency: Lower-performing Schools
Culture		
Group accountability	Almost all	None
Positive climate	All	Some
Curriculum and Assessment		
Planning based on district or school curriculum documents	Almost all	None
Curriculum-aligned assessments	Almost all	None
Commonwealth Accountability Testing System data analysis	All	All
Acceleration		
More time or smaller class size for struggling students	Almost all	Few
Professional Development		
Building-level mathematics instructional support	Almost all	Few
Regular attendance of mathematics conferences, workshops	Almost all	Almost all
Feeder Schools Performing Above State Averages	Almost all	None

Note: The following percentages are associated with qualifiers used in this table: Few=1%-20%; Some=21%-50%; Most=51%-80%; Almost all= 81%-99%. OEA visited 11 higher-performing schools and 6 lower-performing schools. Practices and leadership in a number of site visit schools had changed significantly between the 2008 and 2009 school years.
Source: Staff analysis of site visit data.

Culture

Site visit data identify striking similarities in the culture of higher-performing schools.

Site visit data identify striking similarities in the shared values and norms—commonly called culture—of staff in higher-performing schools. While questions related to school culture were not included in the interviews, teachers and administrators consistently volunteered descriptions of school culture when asked questions about instructional leadership, school working conditions, and factors associated with high performance and continuing challenges.

Findings related to culture are reported in two categories: group accountability and climate.

School culture is described here in two categories: group accountability and school climate. Group accountability characteristics are discussed in greater detail because they were more closely associated with academic achievement than were school climate characteristics and because they were stressed most emphatically by teachers and administrators in higher-performing schools. OEA interviewed mathematics teachers only. In most cases, mathematics teachers reported that group accountability characteristics applied to all content areas and accounted for the general high performance of site visit schools.

Group Accountability

Education research consistently identifies cultures of high achievement in high-performing, high-poverty schools.

Numerous studies have identified cultures of high achievement in high-performing, high-poverty schools. Teachers in these schools report sharing high expectations for students and a commitment to working collaboratively with all school staff to support these expectations (Kitchen et al.; Kannapel and Clements; Anderson). Studies of such schools within the Commonwealth and elsewhere highlight teachers' and administrators' strong sense of personal accountability to meet high standards of practice. These schools also focus on hiring teachers with the qualities necessary to support this culture (Kannapel and Clements; Council).

OEA site visit data support this research while identifying specific characteristics: teachers' accountability for practice; teachers' accountability for each other; administrators' accountability for ensuring good working conditions; and administrators' and teachers' reinforcement of high expectations.

OEA data support these findings and identify specific school characteristics common to schools with a collective commitment to high student achievement. The term "group accountability" is used because it captures both the common commitment of staff in these schools as well as the sense of personal accountability to support high student achievement. Teachers and administrators in higher-performing OEA site visit schools consistently cited the following factors as primary determinants of the school's success:

- Teachers' accountability for practice
- Teachers' accountability for each other
- Administrators' accountability for ensuring good working conditions
- Administrators' and teachers' reinforcement of high expectations

Administrators in higher-performing schools held consistent, high expectations for teachers' classroom practice and their commitment to students.

Teachers' Accountability for Practice. Teachers in higher-performing schools said their principals expected bell-to-bell instruction (no time wasted or sitting at desks); engaging, well-prepared lessons; positive discipline with students; and commitment to providing students with needed academic and social support, no matter what challenges students brought to the classroom. Teachers in higher-performing schools were confident that these expectations applied to all, without exception. Teachers in one low-performing school described similar accountability. Lacking in this school, however, were the other components of group accountability.

Teachers in higher-performing schools reported routinely and voluntarily exceeding minimum work requirements.

Teachers in higher-performing schools held similarly high expectations for their own performance, routinely exceeding work responsibilities outlined by administrators, rules, or regulations.

Teachers reported working for many hours after the regular school day, during summers, planning periods, and lunches. Teachers voluntarily took on additional, unpaid work such as providing/attending professional development or attending committee meetings. Some teachers in lower-performing schools also held themselves accountable to the same standards discussed above; in lower-performing schools, however, teachers and administrators described unevenness in the willingness of all teachers to exceed minimum work expectations.

Teachers in higher-performing schools were recruited for their ability to meet the school's high expectations for classroom instruction and professional commitment.

Recruitment played a central role in building and perpetuating cultures with strong accountability for teaching practice. Administrators and teachers in higher-performing schools stressed the importance of recruiting candidates with the requisite teaching ability, attitude, and professional commitment. Candidates were informed clearly about the professional responsibilities expected of teachers.

Principals attributed school success to the quality of teaching staff. They worried about the ability to replace teachers in the face of retirements or other career changes.

When asked to explain their school's success in mathematics, principals in almost all higher-performing schools stressed the quality and commitment of their mathematics teachers. They explained that, absent these high-quality teachers, the school would not have had the same success. Many principals worried about their ability to replace current teaching staff with teachers of equal quality in the face of retirements or other career changes.

Teachers in higher-performing schools accepted responsibility to support high performance of colleagues, especially those in their immediate work groups.

Teachers' Accountability for Colleagues. Teachers in higher-performing schools felt responsible for supporting successful practice among all colleagues, especially those working in their immediate group; in elementary and middle schools, these groups included grade-level teams or multigrade "families" or "pods" that shared the same students. In high schools, mathematics teachers had closest working relationships with other mathematics teachers. Teachers recognized that the school's success required consistent, high expectations and performance of all teachers. While some teachers in lower-performing schools reported close working relationships with individual colleagues, these relationships were not common to all staff.

Veteran teachers in higher-performing schools assumed formal and informal mentoring relationships with new teachers.

In all higher-performing schools, teachers assumed formal or informal responsibilities for helping new teachers to understand and meet the schools' performance expectations. Mentoring relationships existed for teachers that were new to the profession as well as for teachers who were new to the school. For example, administrators in one school assigned two "shadow" mentors to new teachers—colleagues who provided regular support beyond the mentor officially assigned to that teacher. In another school, new teachers were told explicitly to follow veteran teachers' plans and guidance for the first few years in the school.

Teachers in higher-performing schools felt that administrators were accountable for ensuring good working conditions and that they respected teachers' opinions in the formulation of school policies.

Administrators' Accountability to Teachers. Teachers in almost all higher-performing schools credited their principals for ensuring successful working conditions and being responsive to teachers' concerns. Working conditions frequently mentioned by teachers included interruption-free instructional periods, sufficient classroom resources, and support for student discipline. Whether or not teachers were formally involved in school decision-making bodies—and many were—they credited administrators with respecting teachers' professional opinions in the formulation of school policies.

Many teachers in lower-performing schools expressed frustration at administrative requirements that did not acknowledge teachers' basic classroom challenges.

In contrast, teachers in lower-performing schools felt they were often asked to meet requirements that did not acknowledge basic classroom challenges. Challenges mentioned by teachers included large, multiability groups; poor student motivation; and lack of sufficient classroom materials. Teachers in these schools often expressed frustration with what they felt were arbitrary or unreasonable school policies that were determined without sufficient teacher input.

Administrators in higher-performing schools informally monitored teachers' performance and addressed social and academic concerns quickly and directly.

Reinforcement of Expectations. Administrators in almost all higher-performing schools monitored classroom performance of all teachers and addressed concerns directly.[2] They made frequent, informal classroom observations, provided positive feedback, and raised concerns as they arose. Administrators reinforced expectations for social as well as academic issues. Administrators described addressing issues ranging from a teacher's use of derogatory language with students, to a teacher's lack of variety in instructional strategies, to a group of teachers who appeared cliquish and were not sharing information equally with all colleagues.

Teachers in higher-performing schools appreciated fairness in the way administrators reinforced high expectations.

Teachers in higher-performing schools stressed fairness in the way that administrators reinforced expectations. Teachers felt that expectations applied to all teachers, without exception. Teachers also appreciated the informal and supportive manner with which administrators raised concerns. Teachers expressed faith that administrators would ask and consider their views regarding a

[2] In several high schools, mathematics department chairs were more likely to monitor classroom performance than were principals. Mathematics department chairs did not always observe regularly in all classrooms but did monitor student performance on classroom assessments, offering assistance when needed.

particular concern rather than prejudging them. Finally, teachers felt confident that administrators would not request changes in practice without providing support. For example, administrators might identify a colleague to assist with a particular concern. In many cases, administrators would provide this assistance themselves, reviewing classroom data with teachers, suggesting specific instructional strategies, and modeling strategies. In other cases, they delegated this authority and responsibility to instructional coaches or mathematics department chairs.

Teachers in higher-performing schools reported strong group pressure to perform.

Teachers in higher-performing schools also described strong group pressure to perform. Teachers spoke of striving to meet the standards set by colleagues, including high test scores, and not wanting to compromise the school's reputation for achievement. Several teachers also described reinforcement of group expectations during regular interactions and discussions of practice.

Teachers not meeting expectations in higher-performing schools are not retained.

Both teachers and administrators in higher-performing schools acknowledged an essential relationship between high performance and continued employment. Staff in most higher-performing schools described instances in which individual teachers were unable or unwilling to meet the school's high standards. In these cases, principals reported removing teachers by following procedures outlined in regulations. In some schools, strong recruitment practices had ensured high commitment and ability of all staff to meet the school's high standards, which made disciplinary action unnecessary.

Several principals stressed the importance of school board and superintendent support in principals' abilities to remove ineffective teachers.

Several principals in higher-performing schools questioned commonly accepted beliefs about the difficulty of removing staff for nonperformance, even in the case of tenured teachers. These principals did, however, stress the critical importance of superintendent and school board support for the principal's personnel decisions. Principals agreed that, without this political support, they would have greater difficulty taking steps to remove teachers.

Student Accountability

Almost all high school teachers cited students' lack of motivation as a major barrier to improving student mathematics achievement.

When asked what barriers they faced in helping all students to meet the state's mathematics learning goals, almost all high school teachers cited students' lack of motivation and accountability. As teachers explained, mathematics success at the high school level requires hard work and discipline beyond what has been required of many students in the past. Many students do not see an immediate need to learn advanced mathematics content. Teachers and administrators also reported lack of parental interest in or support for student mathematics achievement.

Consistently higher-performing site visit high schools counseled students and parents, beginning in the freshman year, about the importance of succeeding in rigorous mathematics classes.

Consistently higher-performing site visit high schools met this challenge by counseling students and parents, beginning in the freshman year, about the importance of enrolling and succeeding in rigorous mathematics classes. Two of three consistently higher-performing high schools had a formal process that required parents, teachers, and students to meet and discuss students' goals.

School Climate

Staff in all higher-performing schools cited orderly environments and positive relationships as central factors in the school's success.

Staff in all higher-performing schools cited orderly environments; positive relationships among staff; and positive, caring relationships between staff and students as central factors in the school's success. In several high schools, teachers credited recent gains in mathematics achievement largely to improvements in the school climate, especially higher expectations for the social and academic behavior of students.

Staff in most low-performing schools also reported some positive climate characteristics. Thus, though positive school climates may promote higher achievement in some cases, they can also exist in environments where there is less accountability for achievement.

However, staff in most lower-performing schools also reported some positive school climate characteristics. This suggests that while orderly environments and warm relationships are a necessary prerequisite for high achievement, they can exist in environments where there is less accountability for achievement. School climate findings are reported briefly here, as school climate was not a major focus of this study.

Curriculum and Assessment

Education research has identified the central role of curriculum in high-performing schools. Research has also documented strong effects of specific mathematics curricula on student achievement.

Education research has documented the central role of curriculum in the success of high-performing, high-poverty schools. Curriculum appears to play an important role not only in laying out the specific sequence of skills to be taught but in providing the framework for collaborative work of school staff. Curriculum is not contained in documents alone but in the collective commitment of staff to use, examine, and adapt it (Kitchen et al.; Kannapel and Clements; Council).

Analyses conducted by the federal What Works Clearinghouse also support the critical role of curriculum in promoting high school achievement. The impact of effective elementary mathematics curricula was greater than most other reforms that have been evaluated (Whitehurst).

District or School Curriculum Documents

Teachers' use of district or school curriculum documents formed the blueprint for mathematics teaching and learning in higher-performing schools.

Teachers' use of district or school curriculum documents formed the blueprint for mathematics teaching and learning in higher-performing OEA site visit schools. District or school curriculum documents included the sequence of specific skills to be taught in each grade or course and, in some cases, lessons planned down to the week or day. Teachers stressed the critical function of local curriculum documents in guiding their daily planning as well as aligning expectations of teachers within and across grade levels about the priority content to be addressed in each grade or course.

Local curriculum documents did not guide teacher planning in lower-performing schools. In some lower-performing schools, curriculum documents existed but were not used.

No teacher in lower-performing schools was using locally developed curriculum documents. Expectations for student achievement in lower-performing schools were much less clear; teachers in these schools acknowledged likely gaps in ensuring content coverage among classrooms and grades. In most lower-performing schools, curriculum documents had not yet been developed. However, district curriculum documents did exist in two schools; existence of curriculum documents does not ensure their use.

Teachers described difficulty covering the breadth of content included in the Kentucky Program of Studies.

Limitations of State Curriculum Documents. Teachers in both higher- and lower-performing schools identified limitations of the Kentucky Core Content and Program of Studies documents as guides for classroom planning. Teachers described difficulty deciding how to prioritize teaching of the many skills that are included in Kentucky Core Content. Almost all the teachers interviewed for this study expressed tension between the need to cover required content and the goal of teaching for mastery. In order to cover all content outlined in state curriculum documents, teachers felt they would have to move at a pace that does not allow all students to reach mastery. Additional challenges included redundancy in skills covered from grade to grade, lack of clear grade-level skill requirements in the primary grades, and lack of clear delineation of skills to be taught in particular courses at the high school level.

Curriculum-aligned Assessments

Teachers in higher-performing schools reported alignment of classroom assessments with local curriculum documents. Five of 11 higher-performing schools used classroom assessments common to all teachers.

Almost all higher-performing schools were distinguished by well-developed systems that linked clear expectations for student learning with assessments providing teachers and administrators with continuous data on student achievement relative to expectations. Five of 11 higher-performing schools—and no lower-performing schools—used common classroom assessments developed collaboratively and used by teachers in the same grade or course. Teachers described the benefits of common assessments in aligning expectations among multiple teachers teaching the same course or grade and providing data that allowed teachers to compare effectiveness of instructional practices among classrooms. Common assessments may play an especially important role in high schools. Without these assessments, teachers and administrators lack data that allow comparison of student performance among grades and classrooms.

Interim Assessments

Interim assessments are widely believed to improve instruction and student learning. These assessments are administered several times throughout the school year and provide administrators, teachers, and instructional leaders with standardized student achievement data that can be aggregated across classrooms and schools. In theory, interim assessments can be used by district and school leaders to identify students and classrooms that require additional attention and by teachers to identify specific skill deficiencies in individual students.

Interim assessments were used by most lower-performing schools but few higher-performing schools. These assessments may have limited impact without attention to staffing, scheduling, and curriculum.

Interim assessments were used by a few higher-performing schools and by almost all lower-performing schools in the sample. Data collected for this study are not sufficient to evaluate the general effectiveness of interim assessments relative to expectations. However, teachers and administrators in higher-performing schools tended to apply more scrutiny to the role these assessments would play in their mathematics programs than did those in lower-performing schools. In most lower-performing schools, plans for use of interim assessment data were not clearly formulated prior to purchase and implementation of the assessments. For example, high school teachers in one lower-performing school had access to data about students' skill deficiencies but were not provided with additional time or resources to address these deficiencies. Interim assessments may not have their intended effect in the absence of attention to curriculum, staffing, and scheduling.

Data collected for this study did not allow for systematic analysis of other forms of assessment believed to improve student achievement, such as formative assessment and diagnostic assessment. Appendix E describes formative and diagnostic assessment practices in some higher-performing schools.

Grades and Credit Recovery

Most site visit high schools lacked systems to ensure alignment of course grades and content mastery.

OEA site visit interviews and interviews with state administrators and professional development providers indicate broad variation among Kentucky high schools in grading practices and use of credit recovery. Only two high schools—both consistently high-performing—had clearly defined school grading policies that specified the percentage of each grade comprising test data, homework, and other elements. Most site visit high schools lacked systems to ensure alignment of course grades and content mastery.

OEA observed wide variation among schools in the use of credit- recovery programs for students failing mathematics classes. In consistently higher-performing schools, credit recovery was used modestly or not at all. It is a common option in some schools.

OEA site visit data suggest striking differences between the policies of higher- and lower-performing schools regarding credit recovery for students who have failed mathematics classes. Credit recovery typically allows students to regain failed credits by using software that provides practice and final assessments in the failed content area or through shortened classes during the summer or school year. In the three consistently higher-performing site visit high schools, credit recovery either was not allowed or was allowed only for those students who had failed a class because of lack of effort or attendance. Teachers in these schools expressed doubt that students who had failed to master content in a regular mathematics class would master that content through the credit recovery process. Some teachers also expressed concerns that students may be given inappropriate assistance on assessments in credit recovery classes.

In contrast, credit recovery is a common strategy used in many schools to help students recover lost credits. In one lower-performing high school, students who failed Algebra II were not allowed to retake the course in a regular classroom; they were all enrolled in a credit recovery class. OEA's report on the Extended School Services program found that high school program funds were often used to purchase credit recovery software and to support staff to monitor credit recovery classrooms. These staff were often responsible for monitoring credit recovery in many content areas. Therefore, students taking an Algebra II credit recovery class were not necessarily paired with a staff member qualified to assist them in learning the Algebra II content.

Commonwealth Accountability Testing System Data Analysis

Higher-performing schools analyze state assessment data and adjust curricula and assessment practices in response to identified weaknesses.

Teachers and administrators in all higher-performing schools reported annual analysis CATS data and subsequent adjustments of curricula and instructional practices in response to identified weaknesses. While teachers in lower-performing schools also reported annual analysis of CATS assessment data, these analyses were less likely to result in adjustments to the school's mathematics program. As with interim assessment data, state accountability data may be more likely to guide improvements in schools with strong core mathematics programs.

Education researchers have documented teachers' tendencies to adjust curriculum and instruction based on the format and content of test items rather than on comprehensive curricular goals.

Influence of Test Content and Format on Instruction. Education researchers have identified some undesirable consequences that can result from analysis of test data. For example, teachers may adjust curriculum and instruction based on the format and content of test items rather than on comprehensive curricular goals. This is especially true in test-based accountability systems (Koretz). Teachers in almost all higher-performing schools attributed at least part of their students' high mathematics KCCT scores to a focus in the classroom on the content and format of test items, especially on the format of open-response questions, which were practiced regularly. Teachers in some schools also acknowledged making adjustments to the curriculum based on analysis of the weights given to different skills on the KCCT.

In general, site visit data did not raise concerns about excessive test preparation practices in site visit schools. However, data collected for this study were not sufficient to determine the extent to which teachers adjusted instructional practices based on test content and formats versus broad curricular goals.

Data collected for this study were not sufficient to determine the extent to which teachers adjusted instructional practices based on test formats versus broad curricular goals. However, OEA staff did not document practices that raised concerns about excessive test preparation in site visit schools. Readers should also be reminded that most higher-performing site visit middle and high schools demonstrated high student mathematics achievement on multiple measures. Therefore, it appears that instructional practices in these schools successfully prepared students to demonstrate mathematics knowledge beyond the content tested and the format used on the KCCT.

Acceleration

While all site visit schools had access to individual-level student data, higher-performing schools were more likely to make scheduling and staffing decisions based on these data.

Higher-performing schools use data to identify student needs and to subsequently address those needs. While all site visit schools had access to individual-level student data, higher-performing schools were distinguished from lower-performing schools by the extent to which they made data-based scheduling and staffing decisions.

Extra Support for Struggling Students

Almost all higher-performing schools provided support for struggling students through either smaller class sizes or extended learning time.

Almost all higher-performing schools provided support for struggling students either through smaller class sizes or through extended learning time. Practices in higher-performing elementary and middle schools included

- small-group supplemental instruction. One elementary school had a common space shared by several classrooms in which teachers and aides provided struggling students or groups of students with individual support.
- extended class times. One middle school had daily mathematics classes of 1 hour 15 minutes for all students.
- supplemental mathematics classes. In several middle schools, struggling students received additional instruction for one semester during the period that was designated for elective classes.

Consistently higher-performing high schools grouped students by ability more than other site visit schools.

Consistently higher-performing high schools grouped students by ability into three course levels.[3] While these courses had different names, they corresponded roughly to advanced classes, regular classes, and classes providing instruction designed for struggling students. Classes for struggling students were adjusted in a variety of ways:

- extra classes. Students were enrolled in a regular Algebra II class and an extra Algebra II lab class. The lab class included varied teaching techniques and homework assistance.
- extended curriculum time lines. Students were enrolled in Algebra Ia and Algebra Ib, courses that extended the regular Algebra I curriculum over 2 years.
- smaller classes. In one school, the pupil/teacher ratio in one course was 5:1.

Teachers in consistently higher-performing high schools reported benefits to students of all levels through ability grouping.

Teachers in consistently higher-performing high schools reported benefits to students of all levels through multilevel ability grouping. Teachers noted differences in the learning styles among students who were able to grasp abstract concepts quickly and those who needed more time to explore concepts through

[3] Higher-performing schools that performed well on the KCCT but not on the PLAN, ACT, and AP tests did not have specially designed classes for struggling students. Instead, these schools provided intensive coaching of select groups of 11th-grade students in the months prior to the 11th-grade KCCT.

manipulatives and models or who needed to receive more explicit instruction breaking down multistep processes.

Teachers in lower-performing schools expressed frustration in their ability to meet the needs of all students during the designated class time.

Few lower-performing schools provided extra learning time or smaller classes for struggling students. Teachers in lower-performing high schools expressed frustration in their ability to meet the needs of all students during designated class time. These teachers reported class sizes of between 27 and 35 that spanned wide ability levels. In general, teachers in lower-performing schools felt they had to choose between covering all the content and moving on before many students were ready, or teaching to the mid- or lower-level students and eliminating material that would have been beneficial to the higher-level students.[4]

Use of EPAS Data To Support Struggling Students

EXPLORE and PLAN may not be widely used to identify and address basic skill deficiencies of students who are not meeting college-readiness benchmarks.

Limited use of EXPLORE and PLAN. Site visit data and interviews with state administrators and professional development providers suggest that EXPLORE and PLAN tests may not be widely used to identify and address basic skill deficiencies of students who are not meeting college-readiness benchmarks.[5]

A variety of factors might explain gaps between the intended and actual use of these tests. First, the EXPLORE and PLAN tests are designed primarily for predicting student readiness through benchmarking rather than for diagnosing students' specific learning needs. Schools do not receive the timely, disaggregated data that would be useful in designing remediation strategies for individual students. Next, administrators and school councils do not always address the staffing and scheduling necessary to

[4] The practice of "tracking" students by ability into different courses has been criticized based on research documenting the detrimental effects of this practice on students assigned to lower tracks (Oakes). As a result, many high schools, including several in the site visit sample, have eliminated tracking practices and directed teachers to meet the needs of individual students by differentiating instruction within mixed ability classes. However, data collected for this report suggest lack of knowledge among high school teachers and administrators about instructional practices that are effective in these settings.
[5] Though almost all high school administrators and teachers acknowledged limitations of EXPLORE and PLAN as diagnostic assessments, some did value these assessments as student motivators. In some cases, students who had not considered going to college were encouraged to do so by high EXPLORE or PLAN scores.

provide extra time and staff to assist struggling students.[6] Finally, many administrators and teachers lack knowledge of effective mathematics intervention strategies for high school students. High school teachers are not generally trained to address basic skills typically taught in elementary or middle school. Supplemental support for struggling students tends to focus more on grade-level content than on basic skill deficiencies.

Accelerated Learning Based on ACT Data

Many schools offer accelerated learning for students scoring below benchmarks on the ACT. Senior-year transitional courses provide students an opportunity to gain skills necessary to pass college readiness exams.

OEA site visit data as well as interview data indicate that students are more likely to receive supplemental instruction for skill deficiencies in their senior year than they are in their freshman year. Many schools offer senior-year transitional courses that provide intervention for students not meeting college-readiness benchmarks for mathematics on the ACT. Students who are successful in these courses, as determined by their scores on schools' college readiness exams, will not be required to take remedial mathematics courses.

Extra Support for High-achieving Students

Higher-performing elementary and middle schools varied in strategies used to support high-achieving students. By high school, however, higher-achieving students were grouped into honors or AP classes.

Higher-performing elementary and middle schools varied in strategies used to support high-achieving students. However, all consistently higher-performing high schools placed higher achieving students in separate classes beginning in 9th grade and systematically prepared them to take AP classes.

Professional Development

Despite consensus about the important role of professional development in promoting teacher and student learning, education research has yet to establish strong links between specific forms of professional development and student achievement.

Despite consensus about the general importance of professional development in promoting teacher learning, instructional improvements, and high student achievement, education researchers have yet to establish definitive links between specific forms of professional development and student achievement. Complicating matters, the term "professional development" has evolved to encompass activities not traditionally associated with it in the past, such as meetings in which teachers discuss student work.

[6] Some teachers and administrators identified block scheduling as a central barrier in their efforts to improve mathematics achievement. Block schedules provide longer class periods than traditional schedules. Schools following block schedules grant credits in semester-long rather than yearlong classes. Thus, students may fulfill mathematics course credits in alternate semesters and go up to 1 year without taking a mathematics class, even under the new graduation requirements.

Site visit data support the general importance of professional development while failing to find clear associations between specific forms of professional development and teachers' reports of learning and instructional improvement.

Site visit data support the general importance of professional development but do not indicate clear associations between specific types of professional development activities and teachers' reports of learning and instructional improvement. OEA observed no systematic differences between higher- and lower-performing schools in the nature, quantity, or duration of training attended by teachers, the organized use of school time for professional learning, or the use of professional development plans or teachers' individual growth plans to guide learning.

Teachers in higher-performing schools expressed a strong collective commitment to professional learning. Professional learning in higher-performing schools may reflect combined effects of professional development and other school characteristics.

Teachers in higher-performing schools did, however, express a strong collective commitment to professional learning that was not expressed by teachers in lower-performing schools. The data suggest that teachers' commitment to professional learning in higher-performing schools may have resulted from the combined influence of professional development activities and other school characteristics such as curriculum, assessment, and accountable school cultures. Support from administrators also appeared to play an important role in fostering conditions that promoted mathematics teachers' professional learning.

Commitment to Professional Learning

Teachers in higher-performing schools expressed a commitment to improving classroom practice, individually and collectively, over time. They consulted many sources in seeking to improve practice and used data to evaluate the impact of particular practices.

Teachers in almost all higher-performing schools shared a common commitment to improving classroom practice over time, both individually and as a group. Teachers explained that when planning instruction, they examine previous practices for strengths and weaknesses and seek to incorporate new tools and strategies that might increase student engagement with or understanding of specific curriculum content. Teachers reported using both formal data such as classroom assessments and informal data such as student observation to identify improvement goals and to evaluate the impact of instructional changes. Teachers looked for resources and new ideas wherever they could find them: colleagues, administrators, conferences, workshops, and online. While teachers cited benefits from a variety of professional development opportunities, they were generally cautious about crediting their professional learning to a specific type of professional development activity.

Factors Associated With Commitment to Professional Learning

Professional learning in higher-performing schools was linked to curriculum-based planning and assessment, teachers' sense of accountability for practice, and teachers' commitment to collaborating with colleagues.

As described above, professional learning in higher-performing schools was embedded in teachers' daily planning and communication with each other and with administrators. Therefore, it was also linked with mathematics program characteristics already identified in this chapter, especially teachers'

- planning and assessment based on specific curricular goals,
- accountability for high standards of individual practice, and
- commitment to improve practice in collaboration with colleagues.

Teachers in almost all higher-performing schools had regular interactions with an administrator or instructional leader who provided mathematics-specific feedback, modeling, or resources. Most of these leaders had backgrounds in mathematics.

Instructional Support. Higher-performing schools were also distinguished from lower-performing schools by the onsite presence of an administrator or instructional leader who was comfortable interacting with teachers about mathematics-specific instructional issues. Most of these leaders had mathematics backgrounds themselves. Five of six higher-performing elementary and middle schools had principals or assistant principals who were former mathematics teachers. In addition, the instructional coach in one higher-performing middle school was a former mathematics teacher. In consistently higher-performing high schools, mathematics department chairs, rather than principals, took an active role in monitoring the overall quality of the mathematics program. Department chairs in these schools monitored classroom data and provided instructional support when concerns arose. In several higher-performing schools, district administrators provided mathematics-specific feedback or support to teachers.

The nature and intensity of instructional support varied among schools and often was informal. Overall, mathematics teachers appreciated the ability of administrators to back up high expectations with support and to interact directly with teachers about their concerns. However, teachers also reported a variety of specific supports provided by leaders. For example, principals with mathematics backgrounds might question the way they observed a concept being taught and offer specific alternatives or pair a teacher with another colleague. In some cases, leaders demonstrated mathematics lessons, accessed instructional materials, and helped teachers to locate external professional development opportunities.

Teachers in lower-performing schools were frustrated by a lack of mathematics-specific support from district and school administrators.

In contrast, teachers in lower-performing schools described administrators who did not discuss mathematics-specific teaching and learning issues or did not provide mathematics-specific support. In some lower-performing high schools, administrators interacted very little with mathematics teachers. In others, school or district administrators directed teachers to make changes without providing clear justification for these changes, full explanations of what they expected, or answers to teachers' questions or concerns about the requested changes. Noticeably absent in lower-performing schools were administrators who could address mathematics teachers' questions or concerns about requested changes. Teachers in most lower-performing schools also expressed frustration with frequent changes in school policies and practices.

Teachers reported benefits from resources and strategies gained from workshops or conferences.

Workshops and Conferences. Teachers in almost all higher- and lower-performing schools reported attending one to two workshops or conferences per year. Teachers appreciated the resources and strategies they had gained from these experiences and the opportunities to network with other mathematics teachers in the state.

Workshops and conferences appeared to have limited effects on schoolwide professional learning in lower-performing schools.

These professional development activities did not appear to be the primary factor promoting professional learning in site visit schools. Teachers in higher-performing schools acknowledged that workshops and conferences alone did not account for the focus on professional learning in their schools. Conversely, these opportunities did not appear to promote schoolwide professional learning in lower-performing schools. Many of the teachers in lower-performing schools had participated annually in the same types of activities described by teachers in higher-performing schools. For example, teachers in one lower-performing school participated in a mathematics professional development project that extended over several years and provided weeklong trainings for many of the school's teachers.

OEA staff found inconsistent relationships between school structures commonly associated with professional learning and professional learning as reported by teachers.

School Schedules. OEA staff found inconsistent relationships between professional learning reported by teachers and school schedules commonly believed to promote professional learning, such as those that include common teacher planning time, frequent teacher meetings, or time for teachers to observe colleagues. Site visit data suggest that while school schedules that formalize frequent teacher interaction can facilitate professional learning in some contexts, they may be neither necessary nor sufficient to promote this goal.

While teachers in a few higher-performing schools had common planning times during which they reviewed assessment data and discussed instructional practices, teachers in most higher-performing schools met formally with mathematics colleagues once a month or less. However, these teachers described frequent, informal discussions with colleagues during lunch, before/after school, and by e-mail.

In contrast, teachers and administrators in several lower-performing schools described unsuccessful attempts to promote professional learning through school schedules. For example, one new principal described frustration at teachers' lack of enthusiasm for collaboration during common planning time. In another school, teachers were required to observe each other but resented the time it took from their planning time and doubted the value of their learning.

There were no observable differences in the degree to which higher- and lower-performing schools complied with state requirements such as professional development days, professional development plans, and teachers' Individual Growth Plans.

Compliance With State Requirements. OEA found no observable differences in the degree to which higher- and lower-performing schools complied with state requirements related to professional development days, professional development plans, or teachers' Individual Growth Plans. In most higher-performing schools, teachers' professional learning activities far exceeded those formally identified in school and district comprehensive plans. Conversely, professional development activities recorded in lower-performing schools' consolidated plans were not always reflective of activities described or valued by teachers. When asked about the nature of professional learning in their schools, teachers and administrators rarely volunteered information about school professional development plans or teachers' Individual Growth Plans.

Feeder Schools Performing Above State Averages

Almost all higher-performing high schools had feeder school student populations whose mathematics performance exceeded state averages. The reverse was true for lower-performing schools. Individual school performance, therefore, often reflects school system performance.

Feeder-school performance appears to be an important component of success in higher-performing schools and a source of challenge for lower-performing schools. Almost all higher-performing middle and high schools benefited from feeder-school student populations whose mathematics performance exceeded state averages. In contrast, all lower-performing middle schools and high schools received students from feeder schools whose performance fell below state averages. Mathematics program difficulties in lower-performing site visit schools reflect underpreparation of the students entering those schools. Policy makers should take into account feeder-school performance when attempting to explain and address the performance of individual middle and high schools. Appendix C reports feeder-school achievement data for site visit middle and high schools.

Common Challenges

Data indicate a number of challenges confronting both higher- and lower-performing schools in their attempts to improve student achievement in mathematics. These include difficulties attracting and retaining high-quality mathematics teachers, students' weak foundational knowledge, effective use of special education teachers, and the tendency of some administrators to focus more on reading than on mathematics.

Regional Differences in the Supply of Mathematics Teachers

Most high school administrators cited difficulties attracting and retaining high-caliber mathematics teachers.

Most school and administrators cited difficulties attracting and retaining mathematics teachers that possess the content knowledge, pedagogical skills, and personal qualities necessary to help students succeed. Administrators in rural areas and in districts with lower property wealth than surrounding districts reported greater challenges recruiting mathematics teachers. The principal of one higher-performing rural high school said that a vacant mathematics position played a role in the school's lower mathematics performance the previous year. A full-time substitute taught the class for most of the year. On the day of the site visit interview, the same principal reported that one of his mathematics teachers had accepted a job in the city where the teacher lived, in order to avoid the long commute. In another district, administrators described difficulty attracting and retaining mathematics teachers because of the substantially higher salaries being paid by a large district in the same region.

Weak Mathematics Foundational Knowledge

Teachers in all site visit high schools expressed concerns about the weak mathematics foundations of many middle school students. These teachers were especially concerned about students' lack of computational fluency and their conceptual understanding of basic operations.

Concerns of Site Visit High School Teachers. Teachers in all site visit high schools expressed concern about the weak mathematics foundations of many students entering high school.[7] Teachers noted that incoming freshmen lacked competency in the skills necessary to succeed in high school mathematics. These skills included computational fluency in addition, subtraction,

[7] Teachers usually raised this concern in response to a question that asked them to describe challenges they face in helping all students to achieve mathematics proficiency.

multiplication, and division; and conceptual understanding of how basic operations relate to each other. High school teachers reported widespread use of calculators by students to make the most basic computations, such as 200 ÷ 50 or ½ + ½ + ½. Teachers also noted students' poor conceptual understanding of fractions and their relationships with decimals and percents. The severity of teachers' concerns varied among the eight site visit high schools. As would be expected, high school teachers in schools with lower-performing feeder middle schools were especially frustrated with entering students' foundational skills. However, even teachers in high schools with higher-performing feeder middle schools expressed concern about student preparedness. In their view, students can perform well on the KCCT 8th-grade assessment without necessarily having the skills they need to succeed in high school mathematics.

The National Mathematics Advisory Panel highlighted national concerns about students' weak mathematics foundations.

Related Research. Research conducted by the National Mathematics Advisory Panel highlighted concerns about the weak mathematics foundational knowledge of many students entering high school. Findings from a survey of 743 algebra teachers identified weak preparation in rational numbers, including students' excessive reliance on calculators, as major concerns.

A study conducted by ACT, Inc. found that student performance on 8th-grade EXPLORE mathematics tests was more predictive of student performance on ACT mathematics tests than high school course work, student background characteristics, and high school grade point average, combined. This finding is especially concerning given the high percentages of Kentucky students who enter high school not meeting proficiency standards on the mathematics KCCT and high school-readiness benchmarks on EXPLORE.

Teachers, administrators, and mathematics educators interviewed for this study identified three instructional practices that they believe account for students' weak mathematics foundations: excessive content coverage; inadequate teaching of the conceptual foundations of mathematics; and insufficient practice with mental computation, including automatic recall of basic addition, subtraction, and multiplication.

Teachers at all levels cited tension between content coverage and content mastery.

Content Coverage Can Undermine Mastery. Site visit teachers at all levels acknowledged tension between the goal of covering required grade-level content and the goal of ensuring student concept mastery. Teachers reported the need to introduce new topics before all students had mastered prerequisite skills. In some cases, teachers had been under more pressure to demonstrate content coverage than they had been to demonstrate student content mastery.

Mathematics educators, district staff, and some teachers cited inadequate teaching of fundamental mathematics concepts as a central cause of students' weak foundations.

Teaching Methods Do Not Support Conceptual Understanding. Mathematics educators, district staff, and some teachers identified another cause of students' weak foundational skills: lack of teaching methods that support students' conceptual development. Students are taught how to complete mathematics problems by following rules and procedures and by memorizing mathematics facts without ever truly understanding their conceptual bases. Thus, when students forget the rules, procedures, and facts, they have no conceptual foundation with which to approach problems. Mathematics educators stress the need to provide preservice training and professional development that hone teaching methods that foster deeper understanding.

Instructional data collected in 32 schools across the state support concerns about insufficient instructional methods.

Instructional data collected through Math Program Improvement Profiles conducted in 32 schools across the state support concerns about the insufficiency of instructional methods used in many classrooms. The data indicate that often students are not given enough time or taught with methods likely to promote conceptual understanding. These data are reported in Appendix B.

High school teachers and administrators describe insufficient attention to mental computation in the elementary and middle school grades. A number of teachers and administrators noted a historical connection between what they perceived as a decline in students' computational fluency and the permitted use of calculators on all parts of the mathematics KCCT.

Insufficient Attention to Mental Computation. Almost all site visit high school teachers and administrators cited insufficient attention to mental computation in the elementary and middle grades as an important factor in students' weak mathematics foundations. They frequently identified excessive use of calculators as both a symptom and a cause of this problem. A number of teachers and administrators interviewed for this study noted a historical connection between what they perceived as a decline in Kentucky students' computational fluency and the permitted use of calculators on the mathematics KCCT. Use of calculators has been permitted on all parts of the mathematics KCCT since 1999. Since that time, Kentucky's test-based accountability system has provided no incentive for teachers to insist on computational fluency without calculators.

Elementary and middle school teachers were far less likely than high school teachers to voluntarily identify concerns about the computational fluency of students entering high school; however, when asked, they acknowledged the validity of high school teachers' concerns.

Elementary and middle school teachers were far less likely than high school teachers to volunteer views about students' computational weakness or use of calculators. However, when questioned directly about these issues, elementary and middle school teachers acknowledged the validity of high school teachers' concerns. Based on the OEA site visit sample, it appears that there may be a disconnect between the priority given to computational fluency among elementary, middle, and high school teachers.

The National Council of the Teachers of Mathematics stressed the critical role of calculators and other computational methods in the mathematics curriculum. The council recommended that students be taught when and how to use different computational methods and that students be proficient in all methods.

Importance of Calculators and Mental Computation. Education researchers and mathematics educators stress the importance of both mental computation and student proficiency with calculators. To date, education research has not established whether and how calculator use might undermine computational fluency.

In a position statement titled "Computation, Calculators, and Common Sense," the National Council of the Teachers of Mathematics stressed the critical role of calculators and other computational methods in the mathematics curriculum. The council provides guidelines for the appropriate use of calculators to extend learning and to prepare students to succeed in a technology-rich world. The council also stressed the continued need for students to be proficient in paper and pencil calculations, number sense, estimation, and quick mental calculations. The council recommended that students be taught when to use calculators versus other methods of computation.

The National Mathematics Advisory Panel called for more research on the possible role of calculators in undermining students' computational fluency.

Need for Additional Research on Relationships Between Calculator Use and Computational Fluency. There is a lack of research to support concerns about the relationship between calculator use and computational fluency. But the National Mathematics Advisory Panel reported that it is important for students to develop automatic recall on their paths to computational fluency. The panel raised concerns about possible relationships between calculator use, automaticity, and fluency in computation. The panel called for additional research on calculator use and its "short- and long-term effects on computation, problem solving, and conceptual understanding" (xix, xxiv).

Teachers allow students to use calculators to compute problems that should be solved quickly and easily using other basic methods. Calculators can also be used to compensate for skill deficiencies.

While questions about calculator use were not included in the OEA site visit interviews, staff heard several reports of calculator practices that could potentially undermine students' computational fluency. Teachers allow students to use calculators to compute problems that should be solved quickly and easily using other basic methods. The result is that students with computational weaknesses move more quickly through material and teachers cover more curriculum content. However, this practice may also deprive students of regular practice with mental computation. Calculators can also be used to compensate for skill deficiencies. For example, students who are not able to add fractions using standard methods may be taught how to add fractions on the calculator. Therefore, they progress to more advanced topics without receiving necessary remedial instruction for foundational skills.

Teachers and administrators in several higher-performing site visit schools described efforts to address perceived weaknesses in students' number sense and computational fluency.

School and District Efforts To Build Computational Fluency. Teachers and administrators in several higher-performing site visit schools described efforts to address perceived weaknesses in students' computational fluency. School staff were motivated to address these issues not because they believed it would raise their KCCT scores but because they believed strong mathematics foundations were important for future learning. In one elementary school, the principal taught teachers how to build students' skills by using mathematics games and other activities. In one middle school, teachers agreed not to allow use of calculators until Christmas. In another, students participated in a schoolwide competition of speed and accuracy in multiplication facts through daily recitation.

Administrators in the Corbin Independent School District (which was not a site visit district) are working with professors at Eastern Kentucky University to develop a districtwide approach to building stronger mathematics foundations. Although student mathematics achievement in this district far exceeds state averages at every school level, administrators and teachers had become concerned that many students' lacked essential mathematics skills including automatic recall of basic facts. Preliminary data suggest relationships between students' automaticity and their performance on other measures (Thomas).

Effective Use of Special Education Teachers

Special education students who have mathematics goals included in their Individualized Education Programs are entitled to assistance from special education teachers in resource rooms or from special education teachers who collaborate with regular classroom teachers. Most students receive assistance from collaborating teachers in regular classrooms.

Special education collaborating teachers are an important resource that can be used to support both special education students and other students struggling in mathematics. This resource is not used effectively in all schools.

Special education collaborating teachers represent an important resource that can be used to support both special education students and other students who are struggling in mathematics; however, site visit and interview data raise concerns about the degree to which this resource is being used effectively in many schools. In the best-case scenario, a special education collaborating teacher can function as an additional classroom teacher, assisting all struggling students and providing much-needed individualized attention. In the worst-case scenario, a special education collaborating teacher is not much more than a physical presence in the classroom, reminding students to pay attention or take out their pencils.

Teachers and administrators in most higher-performing schools described efforts to maximize the impact of special education teachers who collaborate in mathematics classes. In these schools, regular and special education teachers planned and often taught collaboratively. Planning included discussion of specific students and adaptation of instructional materials to meet their needs. In several schools, teachers believed that an outside observer might not be able to discern which teacher was the regular teacher and which the collaborating teacher. In addition, an outside observer might not be able to discern which students were identified for special education; the collaborating teacher helped any student who needed assistance. These relationships between regular classroom and special education teachers were often developed over a period of years and required special education teachers who were comfortable with the content being taught. In some cases, these teachers were placed purposefully in mathematics classrooms by administrators who were aware of their strong content knowledge. In other cases, special education teachers gained mathematics competence over a period of years by observing and working with the regular classroom teacher.

High school teachers noted that many special education teachers lack mastery of mathematics content being taught to students.

In contrast, teachers in most lower-performing and some higher-performing schools expressed frustration with the limited assistance provided by special education teachers to students who were struggling with mathematics content. Almost all high school teachers described current or previous special education collaborating teachers who lacked mastery of the mathematics content being taught. Special education teachers are not required to take mathematics content courses as part of their preservice training. In several schools, special education teachers collaborated in many different content classes and rotated frequently among assignments from year to year. Therefore, they did not have opportunities to establish ongoing relationships with regular classroom teachers or to develop their understanding of content. Further, special education teachers are not always included in professional development provided to mathematics teachers.

Tendency of Administrators To Focus More on Reading Than on Mathematics

District improvement efforts have been focused more on reading than on mathematics.

Most district and school administrators interviewed for this study acknowledged that improvement efforts have been focused more on reading than they have on mathematics. In many district offices, attention had only recently turned to mathematics. Reading is commonly considered to be the prerequisite skill for success in other subjects. As one administrator explained, no one would consider sending a child from middle school to high school who could not read, but there is less concern about sending students from middle school to high school who have weak mathematics skills. Few district administrators reported regular contact with high school mathematics teachers.

The Commonwealth Accountability Testing System previously used in Kentucky would not have identified a school with low mathematics scores as needing assistance if the school had higher scores in other subjects.

The Commonwealth Accountability Testing System previously used in Kentucky did not focus specifically on mathematics. In this system, schools were rated on combined accountability indexes in multiple subjects; therefore, a school with moderately strong scores in other subjects would not be identified as needing assistance for low mathematics scores. Several low-performing site visit schools had not been identified for state assistance despite the fact that their mathematics scores were among the lowest in the state. In contrast, accountability measures associated with No Child Left Behind (NCLB) hold schools accountable for performance in every subject area. Because of this, Kentucky Title I schools receiving funds through NCLB are currently under greater pressure to perform in mathematics than are non-Title I schools. A greater percentage of Kentucky elementary schools receive Title I funding than do middle and high schools.

Chapter 3

Mathematics in Kentucky High Schools: Program Concerns

This chapter presents state data that raise concerns about implementation of new high school graduation requirements and student access to advanced courses.

This chapter presents state data that raise concerns about implementation of new graduation requirements and students' access to advanced courses. Data suggest that the new high school graduation requirements may not have their intended effects in the absence of attention to course design and to broader issues of mathematics program quality discussed in Chapter 2. Data also indicate broad variability among schools in student access to rigorous courses, especially Algebra I in 8th grade and Advanced Placement in high school.

High School Graduation Requirements

Beginning with the graduating class of 2012, Kentucky high school students will be required to take one mathematics class each year that includes Algebra I, Geometry, and Algebra II in order to graduate. These new graduation requirements will increase both the course rigor and the instructional time currently required for high school graduation. Students graduating prior to 2012 are required to take three mathematics classes that include Algebra I and Geometry.

State course-taking and site visit data indicate that Kentucky's new graduation requirements alone may not prepare students to succeed in mathematics at the postsecondary level.

Advocates of the new graduation requirements believe they will increase the number of students who graduate from Kentucky high schools prepared to succeed in mathematics at the postsecondary level. However, state course-taking and site visit data indicate that these new graduation requirements alone are not likely to accomplish this goal.

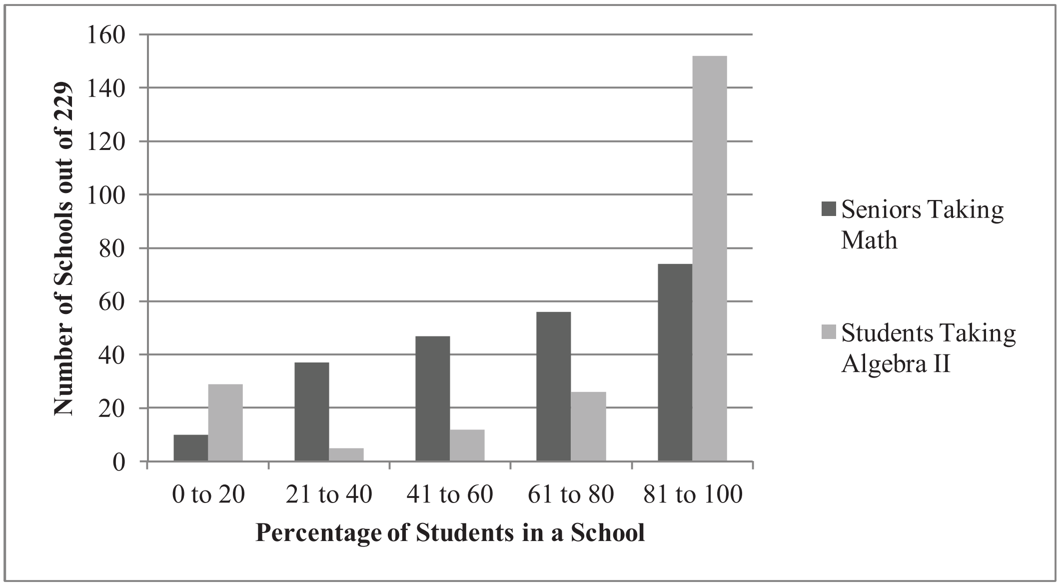
The overwhelming majority of Kentucky high schools had high percentages of students taking Algebra II in 2009. However, most schools will have to increase senior enrollment in mathematics classes to fulfill the new graduation requirements in 2012.

Figure 3.A estimates the percentage of Kentucky students, by school, who were fulfilling the future graduation requirements of Algebra II and 4 years of mathematics in the 2009 school year. As the table shows, the overwhelming majority of Kentucky high schools already had high percentages of students taking Algebra II in 2009. While many schools also had high percentages of seniors taking mathematics classes, most schools will have to increase the number of seniors taking mathematics classes to meet the graduation requirement of 4 years of mathematics.

In 2009, 34 schools enrolled fewer than 40 percent of students in Algebra II, and 47 schools enrolled fewer than 40 percent of seniors in a mathematics class.

Figure 3.A also shows that in 2008-2009, a substantial number of Kentucky high schools were far from meeting the new graduation requirements: 34 high schools enrolled fewer than 40 percent of students in Algebra II, and 47 high schools enrolled fewer than 40 percent of seniors in a mathematics class.

Figure 3.A
Percentages of Current Students Who Would Meet Future Graduation Requirements of Algebra II and 4 Years of Mathematics, by School
2009



Note: Percentages of students taking Algebra II were estimated by dividing the total number of students taking Algebra II in each school in 2008-2009 by the average grade enrollment in each school. Longitudinal course-taking data are not available. This analysis does not include alternative schools, vocational schools, or other schools operated by or as a part of another school. Course-taking data provided by the Kentucky Department of Education (KDE) for this analysis contained incomplete and inaccurate data. KDE attempted to address issues with the data and provided schools with opportunities to correct the data prior to staff analysis for this study.
Source: Staff analysis of Kentucky Department of Education data.

Algebra II Enrollment Does Not Ensure High Achievement

Policy makers should be cautious about expecting dramatic gains from the new graduation requirements, given that the overwhelming majority of students are already fulfilling these requirements in most schools.

Data presented in Figure 3.A suggest that policy makers should be cautious about expecting dramatic gains in student mathematics achievement from the requirement that all students take Algebra II because the overwhelming majority of students in the state already meet this requirement. Further, while the Algebra II requirement may be an important component of student success in higher-performing schools, it does not ensure success in all schools.

Teachers and administrators in higher-performing site visit schools cited rigorous course requirements as important in a school's high student achievement in mathematics.

Teachers and administrators in higher-performing site visit schools cited rigorous course requirements as important in a school's high achievement in mathematics. Five of six higher-performing high schools already required Algebra II for graduation. Staff analysis of state data indicate that schools enrolling an estimated 100 percent of students in Algebra II in 2008-2009 had, on average, proficiency rates of 43 percent, or 2 percentage points higher than the state average.

The requirement to take Algebra II alone is unlikely to promote high student achievement. Student proficiency rates in two lower-performing site visit schools were low despite the Algebra II graduation requirement. In 2009, many high schools had low student proficiency rates despite high Algebra II enrollment rates.

However, many schools had low student mathematics proficiency rates despite the Algebra II course requirement. Staff analysis of state course-taking data suggests that proficiency rates are low in many schools in which students already take Algebra II. In 2008-2009, there were 27 high schools that enrolled an estimated 100 percent of students in Algebra II but that had mathematics proficiency rates of 31 percent or less—10 percentage points or more below the state average. Two of three site visit lower-performing high schools required Algebra II for graduation. Despite this requirement, student proficiency rates in these two schools were only 25 percent and 21 percent, respectively.

Algebra II Course Content

Interview data suggest inconsistency across the state in the content taught in Algebra II. In the absence of formal guidance, course adjustments will likely reflect variation in performance expectations among schools.

Administrators and researchers interviewed for this study raised concerns about the alignment between course names and course content in Kentucky schools. Misalignment of course name and course content is likely to be greatest in courses enrolling students with lower ability levels. Teachers in both higher- and lower-performing site visit schools adjusted content in Algebra II courses enrolling students with lower skill levels. In some cases, teachers reported prioritizing key content to allow more time for mastery. In others, teachers covered as much of the regular course curriculum or textbook chapters as they could before the end of the year. Teachers generally adjusted content on their own, even in schools with established curriculum documents. In the absence of formal guidance regarding course adjustments, high school courses for lower-ability students will likely reflect variation in performance expectations among teachers, parents, and students in individual schools.

Fourth-year Course Options

The impact on student learning of the 4th-year mathematics requirement is contingent on availability of rigorous, appropriate 4th-year course options.

The impact on student learning of the 4th-year mathematics requirement is contingent on availability of course options appropriate to students' skill levels. OEA site visit data indicate inconsistency among schools and districts in the resources and attention given to course options for high school students beyond the core courses of Algebra I, Geometry, and Algebra II.

In some schools, staffing issues limited the number of mathematics courses that could be offered. In these schools, most students opted out of higher level mathematics classes.

Consistently higher-performing high schools offered multiple 4th-year course options suitable for students of different ability levels. These included statistics, AP, and college readiness courses. In contrast, course options beyond Algebra II were limited in lower-performing schools. In these schools, many students opted out of higher level mathematics classes. In one case, senior year options were limited to Calculus or Business Mathematics. Some students in this school were enrolled in Calculus whether or not they were interested in or prepared for the class, simply because there were no other course options that coordinated with their schedules.

Acceleration

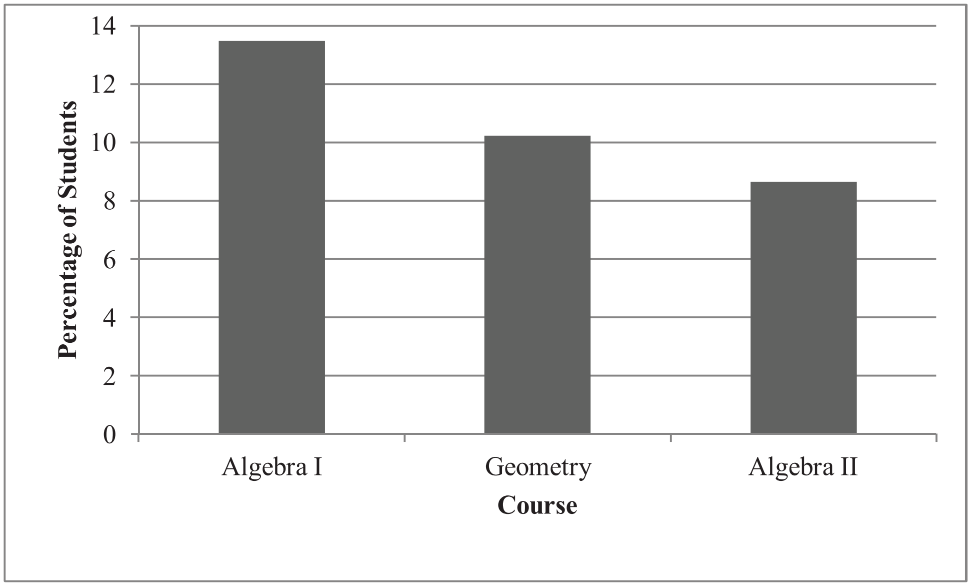
State data raise concerns about insufficient attention to the needs of struggling and advanced learners in many Kentucky middle schools and high schools.

Failure Rates in Courses Required for Graduation

2009 failure rates in Algebra I, Geometry, and Algebra II were 13 percent, 10 percent, and 8 percent, respectively.

Figure 3.B shows 2009 student failure rates in Algebra I, Geometry, and Algebra II. Failure rates in these courses were 13 percent, 10 percent, and 8 percent, respectively. Failure rates, especially in Algebra I, were a concern of many teachers and administrators at site visit schools. Some schools reported Algebra I failure rates as high as 30 percent. Failure rates in Algebra II are likely to increase as students who are not interested in the topic are required to take the course for high school graduation. Failing grades in Algebra I may reflect the general difficulties experienced by some students transitioning from middle school to high school. They also likely reflect difficulties experienced by students entering high school with weak mathematics foundations. Failure rates also indicate the need to focus on course development and teaching methods in high school courses.

Figure 3.B
Students Failing Algebra I, Geometry, and Algebra II, 2009

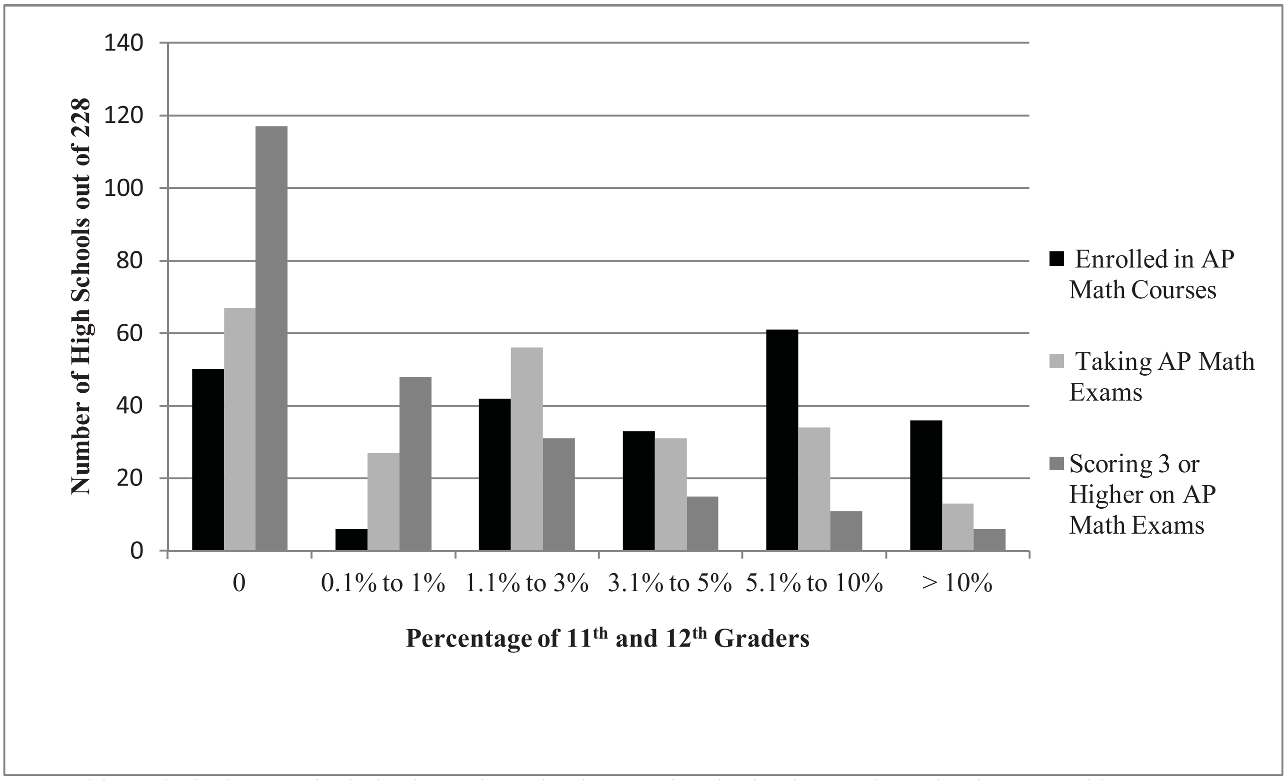


Source: Staff analysis of Kentucky Department of Education data.

Support for Higher-performing Students

Advanced Placement Exams. Advanced Placement courses are the most widely recognized rigorous course options for high school students. Figure 3.C shows variability among Kentucky high schools in the percentages of 11^{th}- and 12^{th}-grade students taking AP mathematics courses, taking AP mathematics exams, and earning qualifying scores of 3 or higher on AP mathematics exams. Of the 228 public high schools in Kentucky, 50 enrolled no students in AP mathematics classes; and more than half, 117, had no students who earned a qualifying score of 3 or higher during the 2009 school year. Conversely, there were only six schools in which greater than 10 percent of students earned qualifying scores of 3 or higher.

Figure 3.C
AP Mathematics Course Enrollments, AP Mathematics Exams Taken, and AP Mathematics Exam Scores of 3 or Higher, by School, 2009



Note: This analysis does not include alternative schools, vocational schools, or other schools operated by or as a part of another school.
Source: Staff analysis of Kentucky Department of Education data.

National policy makers have called for increasing the number of students who take Algebra I in 8th grade.

Eighth-grade Algebra. Variability in AP enrollments, test taking, and pass rates in Kentucky high schools likely reflects differences in the degree to which higher-achieving Kentucky middle school students are being systematically prepared for advanced course work in high school.

National policy makers have called for increasing the number of students who take Algebra I in 8th grade. Students who take Algebra I in grade 8 are more likely to keep pace with their international peers. Kentucky's efforts to increase the number of students who enroll in and pass AP mathematics exams also require increasing the number of students who take Algebra I in 8th grade. High school course-taking patterns associated with success on AP mathematics exams typically require that students enter high school having already earned their Algebra I credits (Morton).

Teachers and education researchers caution against enrolling 8th-grade students in Algebra I who have not yet mastered prerequisite skills.

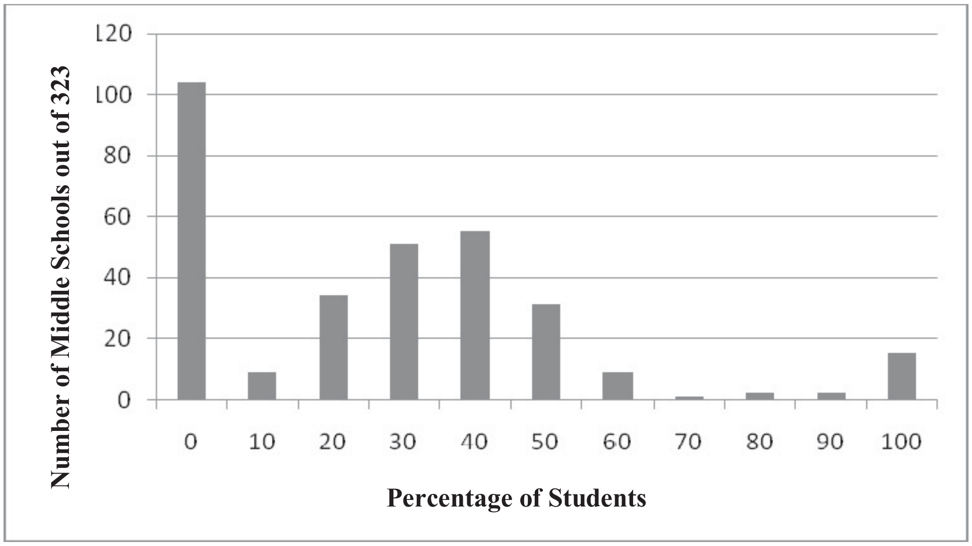
Almost all middle and high school teachers interviewed for this study acknowledged that some students benefit from algebra content in 8th grade but also cautioned against enrolling students in algebra in 8th grade if the students have not yet mastered middle school mathematics skills. Underprepared students may actually perform worse as a result of premature placement in algebra classes (Loveless).

Kentucky middle schools play a key role in ensuring that high-achieving students progress at a pace that prepares them to be successful in AP mathematics courses. At the same time, middle schools must also ensure that students taking Algebra I in 8th grade are prepared for that content. Site visit interviews and interviews with state administrators and professional development providers indicate broad variation across the state in the degree to which middle school and district administrators have focused systematically on the curriculum and assessment issues associated with meeting these goals.

Figure 3.D shows the percentages of 8th-grade students, by school, enrolled in Algebra I during the 2009 school year. Not all students who enroll in Algebra I in 8th grade earn a credit toward the Algebra I credit required for high school graduation. In some schools, credit is not given for taking algebra in the 8th grade. In other schools, students must earn a certain percentage on the final test in order to earn the credit for taking Algebra I in the 8th grade. The figure does not separate the classes offering credit from those not offering credit because those data were not available.

As Figure 3.D shows, in 2009, the majority of Kentucky middle schools enrolled between 20 percent and 50 percent of 8th-grade students in Algebra I. However, more than 100 Kentucky middle schools enrolled no 8th-grade students in Algebra I during that year. OEA staff analysis indicated that 236 middle schools do not offer Algebra I in 8th grade for high school credit. These data raise concerns that large numbers of Kentucky students who may be capable of AP or other advanced course work in high school are not being identified early enough to prepare them to be successful in these courses.

Figure 3.D
Eighth-grade Students Taking Algebra I, 2009



Source: Staff analysis of Kentucky Department of Education data.

Chapter 4

Summary and Recommendations

This report describes 11 higher-performing schools that achieved results by focusing attention on building strong core mathematics programs.

This report illustrates real possibilities for improving the mathematics achievement of Kentucky students. The variables associated with strong core mathematics programs in the 11 higher-performing site visit schools were schoolwide accountability for student learning, a well-defined curriculum, curriculum-aligned assessments, staffing and scheduling to meet student needs, and building-level instructional support for mathematics teachers.

However, too often mathematics is overlooked.

However, too often mathematics is overlooked. District and school administrators have tended to focus more on reading than on mathematics. Unless aggressively counseled by teachers or parents, many students opt out of advanced mathematics courses. In some schools, students are awarded passing grades in mathematics even if they have not demonstrated content mastery. The state's current accountability system provides latitude for low mathematics performance in schools that are performing moderately well in reading.

This chapter summarizes key findings and makes recommendations about what can be done to increase the use of successful practices and confront continuing challenges.

This chapter summarizes key findings and makes recommendations about what can be done to increase the use of successful practices and confront continuing challenges. It focuses on challenges associated with Kentucky's new graduation requirements and the goal of reducing the number of students needing remedial mathematics classes in college. While statutes currently focus attention on accelerated learning in high school, schools must do more to identify and address the needs of struggling students beginning in the elementary and middle school grades.

Given current funding constraints, recommendations focus on efforts that can be accomplished with existing resources. Other challenges, such as regional shortages of mathematics teachers and intervention for struggling high school students, may be difficult to overcome using existing resources. Some of the recommendations for the Kentucky Department of Education may require additional administrative or fiscal resources. State-level efforts to reduce the need for college remediation will require district and school leaders to allocate adequate staffing and scheduling resources.

Group Accountability

Higher-performing site visit schools were characterized by group accountability consisting of the collective commitment of teachers and administrators to high standards of classroom instruction, personal behavior, and student achievement. Staff routinely exceeded minimum job performance expectations.

Higher-performing site visit schools were distinguished from lower-performing site visit schools largely by their "group accountability": the collective commitment of their teachers and administrators to high standards of classroom instruction, personal behavior, and student achievement. In all higher-performing schools, group accountability spurred teachers and administrators to exceed minimum job performance expectations in their commitment to high-quality instruction, continuous improvement, and doing what it takes to meet student needs.

Two aspects of group accountability are specific to mathematics. First is the ability of schools to recruit and retain high-quality mathematics teachers and the ability of principals to remove and replace teachers not meeting expectations. Second is the ability of administrators to back up high expectations for classroom instruction with mathematics-specific guidance and support.

While group accountability extended across content areas in most site visit schools, two characteristics must be understood in mathematics-specific terms. The first is the ability of administrators to back up high expectations for classroom instruction with guidance and support. The second is the ability of a school to recruit mathematics teachers whose teaching expertise and personal demeanor with students are consistent with the school's high expectations. Closely related to this point is the ability of principals to remove—and replace—teachers not meeting expectations.

The ability of schools to attract and retain mathematics teachers is somewhat dependent on school location and district wealth. This is a challenge that some schools and districts will likely have difficulty meeting in the absence of support from the state or federal government. In order to address this issue, the General Assembly would need valid and reliable data on the existence of teacher shortages in mathematics and other areas. Part 2 of this report recommended that the Kentucky Department of Education and the Education Professional Standards Board jointly develop a formula to accurately determine teacher shortage areas, long-term trends, and the hiring needs of the state with a focus on ensuring that teacher availability and quality is equalized across the state (Recommendation 5.1).

Curriculum

Clear grade- or course-level curriculum documents form the blueprint for teaching and learning mathematics in higher-performing schools. In lower-performing schools, curriculum documents either do not exist or are not used.

Higher-performing schools adopt and use clear grade- and course-level mathematics curriculum documents. These documents, developed collaboratively by teachers at the district or school level, form the blueprint for teacher planning, assessment, intervention, and professional learning in higher-performing schools. In lower-performing schools, mathematics curricula either do not exist or are not used. In these schools and district offices, teachers, principals, and district administrators appear unsure of where accountability for adoption and use of mathematics curriculum rests. One district administrator cited the difficulty of developing a mathematics curriculum and requested state assistance.

Local Responsibility for Adoption and Use of Curriculum Documents

Statutes do not assign clear responsibility for adoption and use of curriculum documents.

Given the central importance of a strong school curriculum in shaping mathematics programs, policy makers should ensure that a curriculum is adopted and used in Kentucky schools. However, statutes contain two areas of ambiguity regarding curriculum adoption and use:

- KRS 160.345(2)(i) requires school-based decision making councils to adopt a policy for the "determination of curriculum, including needs assessment, [and] curriculum development…." The term "curriculum" is used broadly and does not capture commonly accepted characteristics of strong mathematics curricula such as the sequence in which specific skills are to be taught.
- KRS 160.290 gives local boards the general responsibility to "provide for courses and other services as it deems necessary for the promotion of education." This statute does not specify the board's role in ensuring that a curriculum is adopted and used.

Given wide variation in student mathematics ability at the high school level, a single course curriculum may not provide sufficient guidance for courses suitable for all student levels.

Adjustment of Curriculum for Different Student Groups. High school teachers in all site visit schools cited the need to adjust course content for students of different abilities. For example, the curriculum for students with lower mathematics skills might cover fewer content areas or cover these areas in less depth. This was especially true in Algebra II courses. Even in schools with curriculum documents, teachers tended to adjust course content on their own. Methods for adjusting content varied broadly among schools and likely reflected different expectations for student performance. Given wide variation in student mathematics ability at the high school level, it is unknown whether a single course curriculum will provide sufficient guidance for courses suitable for all student levels.

Recommendation 4.1

Recommendation 4.1 is that KDE should provide schools with more support when selecting and implementing a curriculum.
A. KDE, in collaboration with the Kentucky Center for Mathematics (KCM) and the Committee for Mathematics Achievement (CMA), should develop definitions of "curriculum" and "needs assessment" as they apply to mathematics and are set out in statute.
B. KDE, in collaboration with KCM and CMA, should develop curricular guidelines for each grade level and course.
C. KDE, in collaboration with KCM and CMA, should develop a consumers' guide to available curriculum materials indicating their alignment with new standards.
D. KDE should disseminate definitions, curricular guidelines, and instructional practices to school boards, school councils, and other educators. KDE should also promote sharing of curriculum documents and instructional resources from successful schools and districts.
E. KDE should develop systematic channels of communication with district and school staff responsible for monitoring and implementing best practices in mathematics.

The statute defining school-based decision making councils' responsibilities for curriculum selection lacks clarity. Additional guidance from the Kentucky Department of Education (KDE) would provide schools with more direction and support when selecting and implementing a curriculum.

A. KDE, in collaboration with the Kentucky Center for Mathematics and the Committee for Mathematics Achievement, should develop definitions of "curriculum" and "needs assessment" as set out in KRS 160.345(2)(i), as they apply to mathematics. The definitions should provide details regarding what is required at the school level when a council is reviewing, identifying, or adopting a mathematics curriculum, including needs assessment, for each elementary or middle school grade level or for each high school mathematics course taught.

B. KDE, in collaboration with the Kentucky Center for Mathematics, the Committee for Mathematics Achievement, and other mathematics curriculum specialists in the state, should develop curricular guidelines with regard to the mathematics content and depth of knowledge for each grade level, and where appropriate, for each course. These guidelines should include, at a minimum, the sequence of specific content to be taught, along with guidance on the development of appropriate needs assessments that could be adopted by schools. These curricular guidelines should include grade- and course-level modifications to meet the diverse needs of all learners. Guidelines should include links to resources, materials, assessments, and model lessons associated with the specific mathematics content included in the curriculum documents, when available.

C. KDE, in collaboration with the Kentucky Center for Mathematics, Committee for Mathematics Achievement, district mathematics teachers, and university mathematics and education faculty, should develop a consumers' guide to available curriculum materials in mathematics. The guide would provide a review and rating of the materials and should indicate how well the curriculum materials align with the content standards adopted.

D. KDE should provide extensive dissemination of the definitions, curricular guidelines, appropriate instructional practices, and associated materials through training opportunities for school boards, school councils, and other educators to ensure full understanding and use by schools

and districts. In addition, the department should promote sharing of curriculum documents and instructional resources from districts and schools that have proven successful in improving mathematics achievement.

E. KDE should develop systematic channels of communication with district and school staff responsible for monitoring and implementing best practices in mathematics teaching and learning.

Linking New Standards and Assessments to Concerns About Students' Weak Mathematics Foundations

High school teachers expressed concern about weak foundational skills of many students. Excessive content coverage, inadequate teaching of concepts, and insufficient attention to mental computation may be contributing factors.

High school teachers in the Commonwealth and the nation expressed concern about the weak foundational skills of many students entering—and graduating from—high school. Concerns included students' inability to complete basic calculations and their insufficient understanding of fractions, decimals, and percents. Interview data indicate three factors that may be undermining students' foundational skills in the Commonwealth: excessive content coverage, inadequate teaching of concepts, and insufficient attention to building and maintaining students' computational fluency. Concerns about content coverage should be addressed in the revision of Kentucky's standards. However, concerns about conceptual development and computational fluency will require shifts in instructional practice.

State administrators and professional development providers are concerned that the teaching methods used in many Kentucky classrooms do not support development of students' conceptual understanding.

The National Council of Teachers of Mathematics and the National Mathematics Advisory Panel stress the importance of developing students' conceptual understanding in building strong foundational skills. State administrators and professional development providers interviewed for this study indicated that the teaching methods used in many Kentucky classrooms are insufficient to ensure that students understand the basis for what they learn in mathematics and that they can apply what they learn in a variety of settings.

The National Council of Teachers of Mathematics recommends students be proficient in different computational methods and be taught when to use them.

The National Council of Teachers of Mathematics stresses the importance of calculators as well as other computational methods, including estimation and mental calculation, in the mathematics curriculum. It recommends that students be proficient in all methods and be taught when to use different methods. The National Mathematics Advisory Panel cited a lack of research documenting detrimental effects of calculator use on calculation skills, conceptual development, or problem solving. The panel also urged caution in the use of calculators to the degree that they impede development of automaticity and fluency in computation and called for more research regarding the appropriate use of calculators (xix, xxiv).

High school teachers interviewed for this study expressed concern about indiscriminate use of calculators in Kentucky classrooms. There is a need for systematic analysis of this issue by state leaders.

While researchers have not yet reached consensus on the relationship between use of calculators and the development of students' automaticity and computational fluency, data collected for this report indicate strong concern among practitioners, especially high school teachers, related to the indiscriminate use of calculators by students to make basic calculations and students' subsequent inability to use other methods. It is as yet undetermined whether widespread calculator use is merely a symptom or a partial cause of students' weak computational fluency; there is a need for systematic analysis of this issue by state leaders.

Recommendation 4.2

Recommendation 4.2 is that KDE and the Council on Postsecondary Education (CPE) should ensure that the new standards focus sufficient attention on building students' foundational mathematics skills.

The Kentucky Department of Education and the Council on Postsecondary Education should ensure that new standards focus sufficient attention on building students' foundational mathematics skills, including developing conceptual understanding of whole number operations and fractions, decimals, and percents; fluency in the use of number operations; number sense; developing and maintaining automatic recall of basic mathematics facts; and appropriate use of calculators.

Recommendation 4.3

Recommendation 4.3 is that KDE, in collaboration with CPE, KCM, and CMA, should ensure that the professional development provided in connection with the new standards include specific guidance regarding the use of teaching methods that support development of strong foundations in mathematics.

The Kentucky Department of Education, in collaboration with the Council on Postsecondary Education, the Kentucky Center for Mathematics, and the Committee for Mathematics Achievement, should ensure that professional development provided in connection with new standards include specific guidance regarding the use of teaching methods that support development of strong foundations in mathematics. This guidance should include methods related to developing students' conceptual foundations as well as developing and maintaining students' computational fluency. Professional development should include guidance on the appropriate use of calculators and the importance of developing and maintaining automaticity.

Acceleration

More attention must be focused on students who are struggling in mathematics as well on students who are capable of higher performance.

Kentucky statutes require schools to provide accelerated learning opportunities for all students in grades 3 and above whose test scores indicate a need for extra support in meeting state learning goals. Statutes also require schools to provide accelerated learning opportunities for more-advanced students who are capable of exceeding state learning goals. Data presented in this report highlight the need to focus more attention on both of these student groups, especially those in the middle schools and high schools. The report also makes clear that effective acceleration will demand cooperation between state and local leaders.

Extra Support for Struggling Students

Site visit and interview data indicate a lack of systematic intervention in the early high school years for students with basic skill deficiencies. Many schools are now providing intervention in transitional courses for seniors.

Kentucky statutes place strong emphasis on the need to accelerate learning for high school students not meeting high school and college-readiness benchmarks as currently measured by the EXPLORE in 8th grade, the PLAN in 10th grade, and the ACT in 11th grade. Site visit and interview data indicate limited use of EXPLORE and PLAN data to provide struggling students with accelerated learning opportunities. However, many schools are beginning to use the ACT to place seniors in transitional courses intended to prepare them for college course work. These senior-year courses may provide support for students who are not prepared for college; however, research suggests that students in senior-year transitional classes may have had more success in mastering high school mathematics content if they had received extra support much earlier. This concern also applies to students who fail Algebra I, Geometry, and Algebra II. In 2009, student failure rates in these courses were 13 percent, 10 percent, and 8 percent, respectively. Failure rates for Algebra I are as high as 30 percent in some schools.

Staffing and scheduling challenges and lack of high school-appropriate intervention resources constitute obstacles to acceleration in high school.

Challenges associated with staffing, scheduling, and a lack of instructional resources explain the failure of many schools to provide early support for struggling students. High schools generally do not have the mathematics staffing and scheduling flexibility necessary to offer struggling students extra assistance in their core classes of Algebra I, Geometry, and Algebra II in addition to accelerated learning to address deficiencies. Further, high school teachers and administrators report little knowledge of instructional strategies that are effective with high school students needing systematic intervention.

Greater focus must be placed on intensive acceleration of students through the elementary, middle, and early high school years. While state leaders can play a critical role in making strategies available, local leaders must make the staffing and scheduling decisions required for acceleration. Elementary schools have greater flexibility than do middle schools and high schools in allocating resources for this purpose.

Greater focus must be placed on intensive acceleration of students through the elementary, middle, and early high school years. Ensuring accelerated learning opportunities for these students will demand efforts by state and local leaders. The General Assembly has directed the Kentucky Board of Education, CPE, and KDE to develop strategies for reducing percentages of students requiring college remediation. State leaders can play a critical role in helping schools to locate, implement, and evaluate intervention programs such as those already identified by the Mathematics Achievement Committee and the Kentucky Center for Mathematics.

However, site visit data suggest that some district and school administrators are not aware of these resources. In addition, the General Assembly should be aware that the success of any strategies developed by state leaders will rest largely on the interest and ability of local leaders to provide the instructional time and staff necessary to implement strategies. Principals, working through school-based decision making councils, must make time in students' schedules and match them with staff capable of providing effective support. In some cases, this may require the school councils to make strategic decisions about reallocating staffing positions within the school. Elementary schools have more flexibility than do middle or high schools in making staffing and scheduling accommodations for accelerated learning.

State leaders should clarify priority concerns in accelerating students with skill deficiencies.

State leaders should clarify for schools the priority concerns that must be addressed through accelerated learning. Schools are currently required to provide accelerated learning for all students with identified skill deficiencies. Schools may need assistance, however, in developing appropriate levels of accelerated learning for individual students. This may be especially true in schools in which the majority of students have skill deficiencies.

Recommendation 4.4

Recommendation 4.4 is that KDE, in collaboration with KCM and CMA, should consider the potential of the new assessment system to identify students who lack the foundational skills necessary to learn grade-level mathematics content.

The Kentucky Department of Education, in collaboration with the Kentucky Center for Mathematics and the Committee for Mathematics Achievement, should consider the potential of the new assessment system to identify students who lack the foundational skills necessary to learn grade-level mathematics content. These students should be identified separately in the reporting of annual assessment data to schools. Assessment reports should be accompanied with reference documents that delineate state and other resources that can be used to provide accelerated learning for these students.

Extra Support for Advanced Students

There is broad variation in the degree to which higher-performing middle and high school students are provided access to challenging course work through Algebra I in the 8th grade and through Advanced Placement mathematics courses.

Data presented in this report indicate broad variation in the degree to which advanced middle and high school students are provided access to challenging course work. Nearly one-third of Kentucky middle schools do not provide opportunities for students to take Algebra I in 8th grade. Nearly one-fourth of high schools have no students enrolled in AP classes. These data suggest that higher-performing students may not have adequate access to challenging course work.[1]

With the improvement of the collection of course data, KDE will have access to more accurate data on the courses offered by schools. Recognizing the need for sufficient access to challenging mathematics course work, it is important for KDE to monitor the courses offered by schools.

Recommendation 4.5

Recommendation 4.5 is that KDE should identify and advise districts and schools when it is determined that Algebra I in the 8th grade and Advanced Placement opportunities are not available to students.

When accurate course code data are available statewide, the Kentucky Department of Education should use the data provided by schools to identify and advise schools and districts that are not providing challenging opportunities for students. Specifically, the department should advise districts and schools when it is determined that Algebra I courses are not available at a middle school and when adequate opportunities for Advanced Placement courses are not available at a high school. The department should provide these schools and districts assistance in developing sufficient opportunities for students in higher-level content courses.

Professional Development

Need for External Partners

Data suggest a continuing need for relationships between teachers, administrators, and external partners capable of introducing and supporting best practices in mathematics.

Mathematics Program Improvement Profile data and interviews with professional development providers indicated that recognized best practices are not being used consistently in Kentucky classrooms. Districts and schools will require assistance from external partners capable of promoting district, school, and teacher practices that are consistent with the new standards. For example,

[1] While all Kentucky high school students have access to AP mathematics exams through the Kentucky Virtual High School, many students may not be prepared to succeed in these courses.

not enough attention is being given to the goals of developing students' conceptual understanding and students' ability to use technology, both of which are emphasized in the new standards.

Professional Development More Likely To Succeed With Administrative Support

Policy makers should be cautious about expecting significant impact from external professional development without attention to school-level issues such as group accountability, curriculum, assessment, and scheduling. Site visit data suggest that these issues are more likely to be addressed in schools with instructional leaders focused specifically on mathematics.

Policy makers and local administrators should not expect external professional development to have a significant impact on teacher learning and instructional improvement unless attention is paid to school-level issues such as group accountability, curriculum, assessment, and scheduling. OEA site visit data suggest that these issues are more likely to be addressed in schools and districts in which administrators are focused specifically on ensuring program strength in mathematics. In the site visit schools, these administrators tended to have mathematics backgrounds themselves.

Administrators with strong mathematics backgrounds may also be better able to promote teachers' professional learning by communicating specific, high expectations for classroom practice and by providing or locating appropriate support for mathematics teachers. Mathematics teachers in higher-performing site visit schools appreciated the ability of their administrators to understand and help address classroom concerns. In contrast, teachers in lower-performing schools, especially in high schools, were frustrated by interactions with administrators who they felt did not understand the specific challenges faced by mathematics teachers.

Administrators should possess the broad knowledge necessary to develop and monitor strong mathematics programs or to delegate such responsibility. Administrators receive ongoing training in connection with requirements of the Effective Instructional Leadership Act (EILA).

It is not realistic to expect that all districts and schools employ administrators with backgrounds in mathematics; however, a crucial and achievable goal would be to ensure that district and school administrators possess the broad knowledge necessary to develop and monitor strong core mathematics programs or to delegate such responsibility. Administrators receive most of their training through the Effective Instructional Leadership Act (EILA). Staff analysis of 2009 KDE-approved EILA courses indicate that, of more than 800 courses offered, only 16 were related to mathematics.[2]

[2] In the same year, only 21 courses were related to reading. These data suggest a general concern about the lack of content-related professional development offerings for school and district administrators. Administrators can also earn EILA credits by attending the Math Leadership Support Network, run by the University of Kentucky's Partnership Institute for Mathematics Science Education Reform.

Recommendation 4.6

Recommendation 4.6 is that KDE should use resources available in the state including KCM and AdvanceKentucky to develop mathematics-relevant course offerings approved for EILA credits.

The Kentucky Department of Education should solicit or develop more mathematics-relevant course offerings approved to fulfill the requirements of the Effective Instructional Leadership Act. These courses should use resources currently available in the state, including the Kentucky Center for Mathematics, AdvanceKentucky, postsecondary mathematics and education faculty, and practitioners in the state who have been successful at improving student mathematics achievement.

High School Graduation Requirements

This report raises concerns about whether Kentucky's new high school graduation mathematics requirements are likely to yield the intended results.

This report raises concerns about whether Kentucky's new mathematics high school graduation requirements are likely to yield their intended results. High schools must focus first on ensuring strong components of core mathematics programs described in Chapters 2 and 3.

High schools must be prepared to offer Algebra II courses and 4th-year course options appropriate to students of different ability levels.

High schools must also be prepared to offer Algebra II courses and 4th-year course options that are appropriate for students of different ability levels. Consistently higher-performing site visit high schools provided multiple Algebra II and 4th-year course options to seniors; options were limited in other site visit high schools.

High schools must also determine the appropriate use of the credit-recovery process for students who fail courses.

High schools must be prepared for the likelihood that some students will struggle to pass Algebra II. Schools must determine the appropriate use of credit recovery versus extended instructional time or smaller class sizes to assist struggling students. In consistently higher-performing schools, the use of credit recovery is limited. However, credit recovery is widely used in some lower-performing schools.[3] Wide-range use of credit recovery across the state leads to questions regarding its appropriate use. Data collected as part of this study are insufficient to analyze the use of credit recovery in Kentucky high schools.

Recommendation 4.7

Recommendation 4.7 is that KDE should require schools to report the number of students who pass courses by means of credit recovery and should establish a system to monitor and report these data.

By August 2010, the Kentucky Department of Education should require schools to report, through Infinite Campus or other state data-collection systems, those students who have received credit through a credit-recovery course. The department should establish a system to monitor these data

[3] OEA did not obtain credit-recovery data in all site visit schools.

and should report by school the percentage of students passing courses by means of credit recovery.

Recommendation 4.8

Recommendation 4.8 is that KDE and CPE should provide systematic guidance to educators, administrators, and other school leaders to support implementation of the new graduation requirements.

Before the end of the 2010 school year, the Kentucky Department of Education and the Council on Postsecondary Education (CPE) should provide systematic guidance to educators, administrators, and other school leaders to support implementation of the new graduation requirements. Guidance should include Algebra II course options appropriate for students of different ability levels, as well as 4^{th}-year course options that provide appropriate content for students of different levels. The department and CPE should use current course-taking data to identify and communicate with schools at risk of not meeting the new graduation requirements.

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Appendix A

AdvanceKentucky Data

Table A.1 shows the high schools participating in the first two AdvanceKentucky groups.

Table A.1
Groups 1 and 2 High Schools Participating in AdvanceKentucky

Group 1: Began 2009 School Year	Group 2: Began 2010 School Year
Anderson County	Bellevue
Barren County	Bowling Green
Corbin	Bryan Station
Henderson County	East Jessamine
Lone Oak	Franklin-Simpson
Marion County	Graves County
North Laurel	Highlands
Reidland	Hopkins Central
Scott County	Johnson Central
Shelby County	Madisonville North
South Laurel	Hopkins
Warren East	Montgomery County
	Paintsville
	Powell Count
	Warren Central
	West Jessamine

Source: AdvanceKentucky

Table A.2 describes the demographic characteristics of AdvanceKentucky Groups 1 and 2 compared to the state in 2008. Compared to the state, Group 1 schools had fewer students living in poverty and fewer African American students. Group 2 schools had higher student poverty levels than Group 1 schools but still slightly lower than the state. The percentages of minority students in Group 2 schools were similar to the state's overall minority population.

Table A.2
Percentage of Students by Race, Ethnicity, and Eligibility for Free or Reduced-priced Lunch AdvanceKentucky Schools and State, 2008 and 2009

	African American	White	Hispanic	FRL
Group 1	5.5	90.6	2.2	38.9
Group 2	11.1	83.9	2.8	44.6
State	10.6	83.7	2.6	48.4*

Notes: FRL means free and reduced-price lunch; * applies to high schools only.
Source: Staff analysis of Kentucky Department of Education data.

Group 1 and State Achievement Data

Table A.3 compares AdvanceKentucky Group 1 schools and Kentucky non-Group 1 schools in English, mathematics, and science Advanced Placement (AP) exams taken, AP exams passed, and percentages gained from 2008 to 2009. Overall, Group 1 schools increased by 73 percent the total number of AP exams taken in these subjects and increased by 72 percent the total number of AP exams passed in these subjects. These gains are almost 5 times greater than those made by non-Group 1 schools in the number of exams taken and approximately 5½ times greater than non-Group 1 schools in the number of exams passed. Group 1 increased by 61 percent the number of AP math exams taken and by 84 percent the number of AP math exams passed. On the other hand, non-Group 1 schools increased by only 5 percent the number of mathematics exams taken and decreased by 3 percent the number of exams passed.

Table A.3
AP Exams Taken and Passed, and the Percentage Gained
AdvanceKentucky Group 1 Schools and KentuckyNon-Group 1 Schools
2009

		2008		2009		2008-2009	
		#Taken	#Passed	#Taken	#Passed	% Gain Taken	% Gain Passed
Group 1 Schools	English	493	254	920	452	87%	78%
	Math	225	100	362	184	61%	84%
	Science	272	81	435	115	60%	42%
	MSE	990	435	1,708	747	73%	72%
Non-Group 1 Kentucky Schools	English	5,585	2,900	6,666	3,455	19%	19%
	Math	3,003	1,769	3,160	1,724	5%	-3%
	Science	2,430	876	2,824	1,063	16%	21%
	MSE	11,018	5,545	12,650	6,242	15%	13%

Notes: The data reported in this table differ somewhat from those reported by AdvanceKentucky. However, they show similar trends. AP science data were not available for one Group 1 school in 2009. Therefore, AP science data for that school were excluded from the analysis in both years. MSE means Math, Science, and English.
Source: Staff analysis of College Board data.

Differences in Mathematics Gains Among Group 1 Schools

While the majority of schools showed impressive gains in both exams taken and exams passed, four schools made small gains or declined in the number of students passing AP exams. These data likely reflect differences in the student groups as well as in the level of program implementation in different schools.

Appendix B

Mathematics Program Improvement Profile Data

Tables B.1 through B.5 report data collected through Mathematics Program Improvement Profiles (MPIPs) and comprehensive reviews conducted by experienced mathematics consultants in 21 Kentucky elementary and middle schools and in 11 Kentucky high schools between 2006 and 2009. MPIPs are based on data from extended classroom observations; interviews with teachers, students, and administrators; and analyses of school curriculum, assessment data, and documents. Consultants used an evaluation instrument that assessed program quality through standards in leadership, curriculum, instructional programs, professional development, and assessment.

Schools were rated using a measurement that ranked program components from 1 to 5 with 1 indicating inconsistency or lacking, 3 indicating moderate consistency, and 5 indicating complete consistency with best practices in mathematics.

The sample of schools is not necessarily representative of schools in the state. High schools in the sample had student mathematics proficiency rates of approximately 5 percentage points less than the state average high school average proficiency rates for the 2006-2009 school years. Achievement data were not available for elementary and middle schools audited with MPIPs.

As the tables show, audited schools need improvements in all areas in order to be consistent with best practices; none of the categories at any level had average ratings approaching complete consistency with best practices. Schools averaged ratings of moderate consistency with best practices on standards of leadership, curriculum, and assessment. However, high schools were rated as less than moderately consistent with best practices in instructional practices; and schools at all levels were rated less than moderately consistent with best practices in professional development opportunities for teachers.

MPIP data suggest special need for attention to mathematics program quality in the following specific areas that were rated as less than moderately consistent with best practice at all school levels:

- Teachers are able to articulate the school's instructional goals for mathematics.
- Students are given opportunities to learn in a variety of instructional groupings and patterns.
- Students are able to use manipulatives to explore concepts, practice skills, and solve problems.[1]
- Students are able to use computers and other technological tools to learn and extend their understanding of mathematics.
- Students with disabilities, struggling learners, and excelling learners are given opportunities to learn via high-quality, differentiated instruction.
- Students have sufficient time to develop conceptual understanding, to apply concepts to new or real-life situations, and to demonstrate learning in a variety of ways.

[1] The term "manipulatives" refers to physical objects that are used by students to explore mathematical concepts.

Overall, MPIP data indicate the need for improvement in the components of strong core mathematics programs identified through site visit data: curriculum, support for students at different ability levels, and professional learning for mathematics teachers. MPIP data also highlight concerns about instructional practices in Kentucky classrooms. OEA site visits did not include classroom observations.

Table B.1
School Leadership Ratings in Schools Audited With MPIPs
2006-2009 School Years

Standard 1: The School's Leadership/Organization Facilitates Effective Mathematics Teaching and Learning	**Rating 1-5**	
	Elementary and Middle	**High**
1.1 The School Improvement Plan has clearly identified goals for improving mathematics instruction and a strategy to accomplish these goals; teachers of mathematics participated in the development of the plan.	3.2	3.9
1.2 School improvement plans focus on "reducing and/or eliminating" gaps between performance of different groups of students.	3.3	2.8
1.3 Teachers can articulate the school's instructional goals for mathematics and use them in implementing the mathematics program.	2.8	2.6
1.4 Teachers are properly certified for the mathematics in grade level(s) or courses being taught.	4.1	4.6
1.5 Instructional time is appropriate for quality mathematics instruction.	2.9	3.0
1.6 The principal is knowledgeable about and can articulate his/her beliefs regarding a quality mathematics program, has a working knowledge of the current program and vision for improving the achievement of students in mathematics, and personally pursues a professional development program that includes mathematics instruction.	3.4	3.6
1.7 The mathematics instructional program is monitored to ensure use of the school's curriculum and implementation of standards-based, researched-based instruction in all classrooms.	3.7	3.9
1.8 Funds are available and budget allocations sufficient to meet the curricular, instructional, and technological needs generated by the mathematics program at all levels.	3.2	3.2
1.9 The classrooms and school building show evidence of mathematics including posters, student work, bulletin board displays, etc. that stimulate and demonstrate imaginative uses of mathematics.	3.8	3.4
1.10 The mathematics program is reviewed on an annual basis to assess the level of improvement in student learning, needs for professional development, facility and equipment needs, and curriculum and instruction improvement needs.	3.2	3.2
1.11 Both administrative and instructional staff provide regular and consistent communication to families and the community regarding the mathematics program and student performance, including the need for high expectations, support of children in mathematics, curriculum options, and future career opportunities.	3.6	2.5
Standard 1 Average	3.4	3.3

Source: Henderson "Re: High"; Henderson "Re: whoops."

Table B.2
Curriculum Practice Ratings in Schools Audited With MPIPs
2006-2009 School Years

Standard 2: The Written Curriculum Guides Mathematics Instruction and Provides Continuity for the Overall Program		
	Rating 1-5	
	Elementary and Middle	**High**
2.1. A written mathematics curriculum was developed/revised cooperatively by the mathematics staff and administration (both school and district), is used by teachers for planning the instructional program, and is aligned with state standards.	3.1	3.5
2.2. Teachers demonstrate understanding of the mathematics curriculum and ability to teach appropriate grade-level content integrated with mathematics processes of problem solving, communication, connections, representation, and reasoning.	2.8	3.0
2.3 Teachers collaborate to ensure a continuum of learning in mathematics for all students.	3.2	3.6
Standard 2 Average	3.4	3.3

Source: Henderson "Re: High"; Henderson "Re: whoops."

Table B.3
Instructional Practice Ratings in Schools Audited With MPIPs
2006-2009 School Years

Standard 3: An Effective Instructional Program Engages ALL Students in a Variety of Differentiated Mathematics Learning Experiences Resulting in High Achievement	**Rating 1-5**	
	Elementary and Middle	**High**
3.1 Students determine and apply problem-solving strategies for routine and nonroutine problems; justify solutions by communicating mathematically using written, hands-on, verbal, and symbolic representations; and reflect on their work.	3.5	2.8
3.2 Students have opportunities to learn in a variety of instructional grouping patterns appropriate for different tasks and diverse learning styles.	2.7	2.3
3.3 Students use manipulatives to explore concepts, practice skills, solve problems, and verify mathematical reasoning.	2.8	2.0
3.4 Students use computers and other technological tools to learn, interpret, communicate, and extend their understanding of mathematics.	2.2	1.5
3.5 Students use calculators and related equipment in mathematics lessons to develop and extend their understanding of mathematics.	2.6	3.4
3.6 Teachers orchestrate effective classroom discussion by using a good balance of appropriate convergent and divergent questions and questioning strategies that encourage student participation and learning and development of higher-order and critical thinking skills.	3.6	2.8
3.7 Students with disabilities, struggling learners, and excelling learners are provided equal opportunities to learn via high quality, differentiated instruction in mathematics by highly qualified mathematics teachers.	2.7	2.7
3.8 Students engage in solving mathematics problems related to their interests and experiences, or set in real-life situations.	3.3	3.2
3.9 Students are provided sufficient time in mathematics class to develop conceptual understanding, apply concepts to new and/or real-life situations, and demonstrate in various ways what they have learned.	2.6	2.4
Standard 3 Average	3.0	2.7

Source: Henderson “Re: High”; Henderson “Re: whoops.”

Table B.4
Professional Development Practice Ratings in Schools Audited With MPIPs
2006-2009 School Years

Standard 4: Mathematics Teachers and Administrators have Significant, Effective and Ongoing Professional Development Opportunities in Mathematics Content and Pedagogy		
	Rating 1-5	
	Elementary and Middle	High
4.1 The design of the professional staff development program for mathematics is based on both individual and program needs assessments.	2.9	2.4
4.2 The school and district support teachers' continuing education in mathematics by providing time, financial resources and/or opportunities for all of them to expand their mathematical knowledge or strategies for teaching mathematics.	2.5	3.1
4.3 Mathematics teachers participate in varied professional experiences that build on their current knowledge, skills and attitudes; professional development programs are evaluated for impact on teachers' mathematics knowledge and/or on instructional practice in the classroom.	2.4	3.0
Administrators encourage and fund active involvement in local, state, and national professional mathematics associations, societies, and research activities.	2.3	2.7
Standard 4 Average	2.5	2.8

Source: Henderson "Re: High"; Henderson "Re: whoops."

Table B.5
Assessment and Evaluation Practice Ratings in Schools Audited With MPIPs
2006-2009 School Years

Standard 5: Formative and Summative Data are Continuously and Effectively Used To Evaluate and Modify the Mathematics Program	Rating 1-5	
	Elementary and Middle	**High**
5.1 Assessment and evaluation focuses on mathematics content consistent with state and national standards.	2.7	3.2
5.2 Assessment tasks are varied and consistent with good instructional practice.	3.1	3.0
5.3 Expectations for mathematics achievement are clearly communicated and understood through success criteria, rubrics, scoring guides, etc.	3.3	3.0
5.4 Teachers use formative assessment strategies to monitor the performance of students in learning mathematics, to uncover students' prior understandings about the concepts to be addressed, and to address their misconceptions/incomplete conceptions.	3.3	3.4
5.5 Teachers provide timely feedback (focused, descriptive, and qualitative) that moves learners forward; students use feedback on their performance from teachers and peers to improve their work.	3.1	3.2
5.6 Assessment/evaluation data is used to make curricular and instructional decisions at both the individual classroom level and the school level.	3.4	3.8
5.7 Teachers are knowledgeable about assessment practices and adequate time/ support is provided for development and use of assessment resources.	2.7	2.8
5.8 Students of both genders, different races and/or ethnic backgrounds, and different socioeconomic status perform similarly on assessments.	2.8	2.8
Standard 5 Average	3.0	3.1

Source: Henderson "Re: High"; Henderson "Re: whoops."

Appendix C

Site Visit Sample Methodology

Site visit sample methods used by the Office of Education Accountability (OEA) were designed to identify schools that have been relatively more successful than other schools with similar percentages of students eligible for free or reduced-priced lunch in attaining high levels of student mathematics achievement. While the site visit sample included schools with a range of student poverty levels, it excluded schools with less than 20 percent student poverty. Lower-poverty schools are not likely to face challenges that are typical of schools in the state.

OEA staff chose site visit schools based primarily on the percentage of the school's students eligible for free or reduced-price lunch during the 2008 school year and the school's Kentucky Core Content test (KCCT) mathematics index in that year. First, staff generated linear regression equations for elementary, middle, and high school grade levels with the percentage of students eligible for free or reduced-price lunch as the independent variable and the mathematics index as the dependent variable for all Kentucky A1 schools. (A1 schools are those schools that are not alternative schools, vocational schools, or other schools operated by or as part of another school.) Staff then used these functions to generate a predicted mathematics index for each elementary, middle, and high school based on the percentage of students eligible for free or reduced-price lunch in that school. Staff compared each school's mathematics index for 2008 with its predicted mathematics index for 2008 and ranked elementary, middle, and high schools based on this observed minus predicted score.

Staff considered the following additional criteria when choosing higher-performing site visit schools:

- higher performance or improvement over time
- geographic diversity
- absence of selective admissions policies
- poverty rates above 20 percent
- above-average student performance on multiple indicators

Staff attempted to choose higher-performing schools that performed above state averages on multiple indicators of mathematics achievement. For example, in addition to KCCT mathematics achievement data, staff analyzed high schools' PLAN mathematics scores, their ACT mathematics scores, and the percentages of their 11th- and 12th-grade students who attained passing scores on mathematics Advanced Placement (AP) exams. Staff also analyzed middle school EXPLORE scores. Staff were concerned that schools with higher KCCT scores but lower PLAN, ACT, EXPLORE or AP scores would not be using practices likely to promote the goal of college readiness. No additional measures were available for elementary schools.

Due to staffing constraints, many higher-performing schools in the state were not visited in connection with this study; at every school level, there are multiple examples of higher-performing schools that are not included in the sample.

Staff attempted to choose lower-performing schools that were characterized more by low student achievement in math than by overall low student achievement. All but one of the lower-performing schools chosen for this sample were closer to the state academic index average in reading than in mathematics.

Table C.1 assigns letter names to site visit schools and shows the number of higher- and lower-performing schools at each school level. Achievement and demographic data for each elementary, middle, and high site visit school are described separately in succeeding tables.

Table C.1
School Identifiers Assigned by OEA to Site Visit Schools

	Elementary			**Middle School**						**High School**							
	Higher		**Lower**	**Higher**				**Lower**		**Higher**					**Lower**		
School Identifier	A	Q	J	C	I	L	G	H	M	E	F	P	D	N	B	K	O

Source: Staff assignment based on analysis of Kentucky Department of Education data.

Table C.2 shows student performance and poverty data for site visit high schools. Staff faced challenges choosing site visit high schools that met the multiple criteria described above. It was especially difficult to find high schools that performed well on multiple measures of student performance but lacked selective admissions criteria or low poverty rates.

Table C.2 shows clear contrasts between student performance in higher-performing high schools E, F, and P and higher-performing high schools N and D. Students in high schools E, F, and P scored high on four measures. These schools are described as "consistently higher-performing high schools" in the report. Students in high schools N and D scored well on the KCCT but performed below state averages on the PLAN and AP exams. High schools N and D were chosen for the sample because they were in a small group of high schools whose student poverty rates met or exceeded state averages and who performed far higher than predicted on the mathematics KCCT. In several instances, higher-performing high schools N and D lacked key math program characteristics reported for high schools E, F, and D.

Table C.2
Student Performance and Poverty Data
Site Visit High Schools

		Higher Performing					Lower Performing		
		Consistently Higher							
		KCCT, ACT , PLAN, and AP Assessments			KCCT and ACT	KCCT Only			
	School	E	F	P	N	D	B	K	O
Indicators	Math KCCT 2008 Academic Index* (state=67.7)	93.5	80.2	83.3	79.5	79.8	55.6	53.5	57.8
	Math KCCT 2008 Percent Proficient (state=39)	65	52	52	47	42	25	21	29
	Math ACT 2008 Scale Score (state=18.1)	20.2	19.2	19.8	18.8	16.9	17.7	17.3	17.4
	Math PLAN 2009 Scale Score (state=16.4)	17.9	17.4	17.5	16.0	15.5	14.8	16.2	15.9
	Percent 11th and 12th Graders Passing Math AP 2009 (state=1.3)	3.7	1.7	4.0	0	0	0	0.2	0.8
	Graduation Raten2007 Percent of Students (state=83.9)	86.9	85.3	87.7	88.6	79.7	82.8	89.6	94.6
	Percent Student Poverty 2008 (state=48)	37	44	35	48	72	39	41	29

Notes: The most recent data available were used. Not all data are from the 2008 school year. *KCCT mathematics index scores can range from 0 to 140.
Sources: Staff analysis of Kentucky Department of Education data for KCCT, ACT, PLAN, student poverty, and graduation rate; staff analysis of College Board data for AP passing rates.

Table C.3 shows student performance and poverty data for site visit middle schools. Three of four higher-performing middle schools were approaching or exceeded state poverty rates and performed well on both the KCCT and EXPLORE exams.

Table C.3
Student Performance and Poverty Data
Site Visit Middle Schools

		Higher Performing				Lower Performing	
		KCCT and EXPLORE Assessments			KCCT Only		
	School	**C**	**I**	**L**	**G**	**H**	**M**
Indicators	Math KCCT 2008 Academic Index* (state=86)	102.5	99.2	101.6	98.8	72.8	62.6
	Math KCCT 2008 Percent Proficient (state=58)	74	70	71	76	45	35
	Math EXPLORE 2009 Scale Score (state=14.6)	15.8	15.3	15.6	14.2	13.9	13.8
	Percent Student Poverty 2008 (state=52)	45	65	54	82	43	65

Note: The most recent data available were used. Not all data are from the 2008 school year. *KCCT mathematics index scores can range from 0 to 140.
Source: Staff analysis of Kentucky Department of Education data.

Table C.4 reports student poverty and mathematics KCCT data for site visit elementary schools. There were no additional statewide data with which to assess elementary school performance.

Table C.4
Student Performance and Poverty Data
Site Visit Elementary Schools 2008

		Higher Performing		Lower Performing
	School	**A**	**Q**	**J**
Indicators	Math KCCT 2008 Academic Index* (state=96.9)	120.4	123.5	71.5
	Math KCCT 2008 Percent Proficient (state=70)	92	92	42
	Percent Student Poverty 2008 (state=59)	67	42	80

Note:*KCCT mathematics index scores can range from 0 to 140.
Source: Staff analysis of Kentucky Department of Education data.

Mathematics Performance of Site Visit Feeder Schools

Table C.5 show links between student mathematics performance in OEA site visit middle and high schools and the prior performance of students entering those schools. Feeder school student populations for seven of nine higher-performing middle and high schools performed well above state averages on the mathematics KCCT. In contrast, feeder school populations in all five lower-performing middle and high schools performed below state averages. These data highlight the importance of focusing on high student mathematics achievement at all grade levels. Kentucky middle schools and high schools face great challenges ensuring high student mathematics achievement when students enter their schools underprepared.

Table C.5
Site Visit and Feeder School Performance
Math KCCT

	High Schools								Middle Schools					
	Higher Performing					Lower Performing			Higher Performing				Lower Performing	
	E	F	P	D	N	B	K	O	C	I	L	G	H	M
Site visit school percent proficient 2008	65	52	52	47	42	25	22	30	64	59	60	72	40	37
Points +/- state average	+27	+14	+14	+9	+4	-13	-16	-8	+13	+8	+9	+21	-11	-14
Feeder school percent proficient 2005	55	57	42	55	25	27	27	35	81	45	69	53	40	38
Points +/- state average	+19	+21	+6	+19	-11	-9	-9	-1	+36	0	+24	+8	-5	-7

Source: Staff analysis of Kentucky Department of Education data.

Appendix D

Site Visit Interview Methodology

For each site visit school selected, Office of Education Accountability (OEA) staff conducted the following interviews:

- **Teachers**. At least two math teachers who had been at the school for at least 2 years. Teacher interviews frequently included special education teachers.
- **School Administrators**. School principal and any other building-level administrators or instructional leaders working closely with math teachers.
- **District Administrators**. Superintendent and any other district administrators or instructional leaders working closely with math teachers or with the site visit school.

Staff interviewed a total of 75 teachers, 29 school administrators, and 48 district administrators. A minimum of two OEA staff were present at each interview. Following completion of all interviews, staff coded interview data for major themes. In the report, interview data are most often aggregated to describe school-level practices but are also reported at the teacher level. The following percentages are associated with the qualifiers "few," "some," "most," or "almost all" as they are used in connection with both schools and teacher:

Few=0%-20%
Some=21%-50%
Most=51%-80%
Almost All=81%-100%

Interview Protocols

Note: For all questions, determine how long the practices have been in place, especially 2006-2007 vs. 2008-2009.

Interview Protocol for Teachers

1. What accounts for the success you have had with student achievement in math?
2. What challenges do you face in helping all students to become proficient in math?
3. How would you describe the working conditions in this school?
4. What kinds of professional learning opportunities do you have in this school?
5. What does your principal expect of you as a math teacher?
6. What indicators matter most to you in evaluating your own performance?
7. What determines the content of your lessons on a daily basis?
8. What instructional resources do you rely on most when planning instruction?
9. What kinds of student data are most useful to you in planning instruction?
10. High school and middle school: will the new graduation requirements—Algebra II and four years of math—require any adjustments in practice at your school?

If time:
How would you describe instruction for special education students in your school?

To what degree are the following important in your instruction:
- Technology
- Calculators
- Manipulatives, models, etc.
- Differentiated Instruction
- Formative Assessment
- Real world connections

Interview Protocol for School Administrators

Overview

1. What are your school's strengths in math teaching and learning?
2. What are your top concerns about math teaching and learning?
3. How are you addressing/do you plan to address these concerns?
4. What strategies are working well or have worked well in the past? Less well?
5. What challenges are faced by districts and schools in meeting math performance expectations for all students? What particular challenges are faced by your school?

Curriculum and Assessment

6. What determines the content of the curriculum in each grade/course?
7. What types of assessment data impact decisions about teaching and learning at the school and classroom level?
8. How is the new graduation requirement—Algebra II and four years of math by 2012—going to impact your school?

Schedules

9. Can you explain how students are assigned to different math classes?
10. Are there any students who receive supplemental assistance in math?
11. How much planning time do teachers have? Common planning time?

Instruction

12. What do you look for in high quality math instruction?
13. How is math instruction monitored in your school?
14. To what degree have you observed the following in math instruction:
    - Technology
    - Manipulatives, models, etc.
    - Differentiated Instruction
    - Formative Assessment
    - Real world connections

Professional Learning

15. What are the professional learning opportunities for teachers of math at this school?
16. What impact do you believe professional learning opportunities have had on teaching and learning at this school?
17. What challenges do you face in providing professional learning opportunities for teachers of math?
18. What impact do master's degree classes have on the classroom performance of math teachers?

Staffing

19. Do you have difficulty attracting or retaining high quality math teachers?
20. How well do you think new teachers are prepared to teach math?
21. How do you determine staff assignment to particular courses or classes?

Other

22. How do you plan to use your Title I and IDEA stimulus dollars?
23. Have you received assistance from any state support personnel (HSE, ASSIST, VPAT)?

Interview Protocol for District Administrators

Overview

1. What are your district's strengths in math teaching and learning? Strengths at the site visit school?
2. What are your top concerns about math teaching and learning in the district? At the site visit school?
3. How are you addressing/do you plan to address these concerns?
4. What strategies are working well or have worked well in the past? Less well?
5. What challenges are faced by districts and schools in meeting math performance expectations for all students? What particular challenges are faced by the site visit school?

Curriculum and Assessment

6. What role, if any does the district play in shaping the math content taught in various grades or courses?
7. Does the district use any interim math assessments?
8. How is the new graduation requirement—Algebra II and four years of math by 2012—going to impact your district?

Instruction

9. What do you look for in high quality math instruction?
10. Does the district play any role in monitoring the quality of math instruction?
11. To what degree have you observed the following during math instruction in the district? At the site visit school?
    - Technology
    - Manipulatives, models, etc.
    - Differentiated Instruction
    - Formative Assessment
12. How do schools address performance and ability differences among students?

Professional Learning

13. Does the district play any role in providing professional learning opportunities for teachers of math?
14. What are the professional learning opportunities for teachers of math at the school?
15. What impact do you believe professional learning opportunities have had on teaching and learning at the school?
16. What challenges do you face in providing professional learning opportunities for teachers of math?
17. What impact do master's degree classes have on the classroom performance of math teachers?

Staffing

18. Do you have difficulty attracting or retaining high quality math teachers?
19. How well do you think new teachers are prepared to teach math?

Other

20. How do you plan to use your Title I and IDEA stimulus dollars?
21. Have you received assistance from any state support personnel (HSE, ASSIST, VPAT)?

Appendix E

Formative and Diagnostic Assessments

Formative Assessment

Formative assessment is widely acknowledged as an effective instructional strategy, especially for students who are struggling to master academic content. The term as it was originally documented in research describes teachers' use of classroom data to probe student understanding; adjust instruction; and, in collaboration with students, set specific learning goals (Black and William). OEA was not able to analyze formative assessment practices in site visit schools because of lack of classroom data collected. However, teachers in higher-performing schools consistently described some common formative assessment practices:

- Weekly assessments of student progress; use of data to develop flexible groups for the following week
- Use of unit test data to identify student weaknesses to be addressed within the following unit; inclusion of content areas of continuing need in successive units and assessments
- Frequent quizzes, with follow-up support for poorly scoring students and up to three quiz retakes
- Class-opening activities and closing activities designed to provide daily checks of student understanding

Teachers in some lower-performing schools also reported use of opening and closing activities but were less likely to describe other types of formative assessment. However, the nature of site visit data collected do not allow strong comparisons of formative assessment practices between higher- and lower-performing schools.

Diagnostic Assessment

Diagnostic assessments allow teachers to go beyond data provided by state or interim assessments and to identify the precise nature of a student's learning difficulties. OEA staff interviewed a mathematics intervention teacher and two regular classroom teachers in one higher-performing elementary school about the use of the primary-level diagnostic assessments. The teachers were unanimous in citing the advantages of these assessments at addressing fundamental learning needs that had not been identified previously through regular classroom assessments. In this school, teachers were adapting diagnostic tools used by the mathematics intervention teacher for use in their own classrooms.