October 2017

Vertically Aligned Curricular Framework

Profile of Practice Brief

Courtney Tanenbaum, Ed.D.
Kirk Walters, Ph.D.
Arayle Freels
Toni Smith, Ph.D.

Contents

1 Introduction

Introduction

High school graduation rates in the United States are at their highest in U.S. history—81 percent (NCES, 2015). Even so, nearly one in five students nationally does not graduate from high school, and dropout rates are particularly high for low-income students, racial and ethnic minorities, and students with disabilities (National Center for Education Statistics, 2015). Though students drop out of high school for a variety of reasons, research consistently reveals that students who fail Algebra I are at an especially high risk (e.g., Oriheula, 2006; Silver, Saunders, & Zarate, 2008). Algebra I, or its equivalent, is typically required for graduation from high school and is a critical gateway course to more advanced mathematics and science courses as well as potential postsecondary degree pursuits (e.g., Ham & Walker, 1999; Helfand, 2006).

Requiring Algebra I of all students does not on its own guarantee that students will succeed in gaining the content knowledge and skills they will need to advance in their education pathways. For example, students who are underprepared for Algebra I may struggle in the course and these challenges could set them on a path toward gradual educational disengagement—not just with mathematics, but with school (Stoelinga, & Lynn, 2013). However, districts and schools can engage in at least five research-based strategies that may promote student success in Algebra I: instructional practices, professional development, instructional coaching, curriculum alignment, and supplementary learning supports for struggling students.[1]

To share information about these strategies, the U.S. Department of Education's High School Graduation Initiative (HSGI) funded the Promoting Student Success in Algebra I (PSSA) project at American Institutes for Research (AIR).[2] PSSA is designed to provide actionable information for educational program developers and district and school administrators in three ways. First, a series of research briefs summarizes research on the five strategies above that HSGI grantees are implementing to help struggling students succeed in Algebra I. Second, the project includes a forum for practitioners—district program developers or administrators and teachers—to make connections between the findings from the research briefs and their daily work. The results of these discussions are published in a series of perspective briefs. Third, the project includes profiles of practice that provide an in-depth look at the implementation of these five strategies.

[1] For research summaries on each of these strategies, see Sorensen, 2014; Smith, 2014a, 2014b; Walters, 2014a, 2014b.

[2] This brief contains examples of, adaptations of, and links to resources created and maintained by other public and private organizations. This information, gathered in part from practitioners, is provided for the reader's convenience and is included here to offer examples of the many resources and models that educators, parents, advocates, administrators, and other concerned parties may find helpful and use at their discretion. These materials may contain the views and recommendations of various subject matter experts as well as hypertext links, contact addresses, and websites to information created and maintained by other public and private organizations. The opinions expressed in any of these materials do not necessarily reflect the positions or policies of the U.S. Department of Education (Department). The Department does not control or guarantee the accuracy, relevance, timeliness, or completeness of this outside information. Further, the inclusion of links to resources and examples do not reflect their importance, nor is it intended to represent or be an endorsement by the Department of any views expressed, or materials provided.

One of these five research-based strategies is providing students with a coherent, vertically aligned K–12 curricular framework that is designed to develop and build the foundational algebraic skills students need for success in Algebra I, starting as early as Kindergarten. For example, a vertically aligned curriculum describes what students should know progressively across Grades Kindergarten through 12, linking concepts from grade to grade. This vertically aligned curricular approach in mathematics provides ongoing, cumulative opportunities for students to develop a deep understanding of foundational algebra concepts and prerequisite skills in the elementary and middle grades. Students who are taught using this vertical approach to the curriculum have a solid foundation from which to draw when they take a formal Algebra I course in high school. This is in stark contrast to frameworks in which students experience Algebra I—often unsuccessfully—as a subject brand new to them.

For many years, researchers and national experts have been pushing the United States to develop K–12 mathematics curricular frameworks that create explicit linkages from grade to grade, building student knowledge in a coherent way over time (NCTM, 2006; Schmidt, Wang, & McKnight, 2005). The research indicating the benefits of a vertically aligned curricular framework has led many states to revise their standards or adopt new challenging academic content standards for mathematics that are designed to be vertically coherent.

Given this context, the PSSA project reviewed the best research related to implementing a vertically aligned curriculum to support student preparation for Algebra I and summarized the key findings in a research brief (Smith, 2014a; see http://www2.ed.gov/programs/dropout/curricularalignment092414.pdf). The research presented in this brief was designed to support districts and schools as they implement vertically aligned curricula to promote student preparation for and success in Algebra I. As presented in the brief, the key findings from the research show that strong vertically aligned curricula do the following:

- Focus on skill development and understanding of the critical foundations of algebra (i.e., whole numbers and whole number operations, fractions and fraction operations);
- Expose students to algebraic concepts as an extension of arithmetic; and
- Sequence standards that follow how mathematics is structured as a discipline and the order in which students typically learn the content.

To provide real-world examples of how strong, vertically aligned curricular frameworks are developed and implemented, this brief profiles the experiences of two very different school districts: rural Rhodes County and a large urban center, Parsons

City School District.[3] Despite their differences, both districts intentionally and systematically developed vertically aligned curricula to improve their students' preparation and success in Algebra I. The goal of this profile is not to suggest that other districts mimic these approaches but rather to share experiences and ideas that other districts may adapt to meet their own communities' needs.

The information presented here emerged from visits to the two districts, during which AIR staff conducted interviews and focus groups with district math leaders; school principals; mathematics department chairs and teacher leaders; and mathematics elementary, middle, and high school teachers. AIR also reviewed materials and tools, such as curricular frameworks, mathematics standards, scope and sequence documents, unit assessments, and lesson planning tools.

[3] See the Appendix for sampling, data collection, and analytic methods, including district selection criteria. All names of people and places in this practice profile are pseudonyms.

2 Lessons From the Field

Lessons From the Field

The following lessons reflect the experiences of the two districts profiled in this brief.

- **An intentional, phased-in approach to implementation can ease the transition to a vertically aligned curricular framework.** District leadership buy in and commitment to a vertically aligned curricular framework is a prerequisite for implementation, but on its own is not sufficient to ensure widespread adoption. The move to using a vertically aligned framework typically requires a shift in instructional sequences, materials, and practices across the K–12 system that can feel overwhelming for school leaders and teachers, and can strain district capacity, if implemented too quickly. In recognition of these challenges, Rhodes County and Parsons City intentionally phased in district and school-wide implementation of their vertically aligned curricular frameworks. Rhodes County first implemented a vertically aligned curricular framework in a subset of interested elementary schools. The early adoption of the vertically aligned curriculum in these schools developed a cadre of lead teachers and provided a solid reference for districtwide implementation following the state's adoption of the vertically aligned academic content standards in 2010. Although the schools across the district were at different levels of "readiness" to implement the new curricular framework, the district's early adopting teacher leaders and newly designated district math helped develop resources and tools to ease the transition and to differentiate supports to individual schools and teachers. Parsons City phased in its implementation of the framework across all schools and grade levels by focusing the first year of on supporting teachers' implementation of the mathematical practices standards of the framework and the pedagogical shifts that these practices standards required. The district perceived the practices standards as foundational for quality implementation of the mathematics standards (e.g., the foundational algebraic skills such as whole numbers and fractions and the sequencing of the standards across vertical grade levels), which was the focus of the second year of implementation. The initial focus on the mathematics practices standards also ensured that students were still being assessed on the content they were learning as the assessments that were aligned to the vertically aligned curricular framework were not in place until the second year. This gradual approach to implementation allowed teachers the opportunity to learn the two sets of standards in the framework over time and adapt the delivery of their instruction and lesson activities accordingly.

- **Professional development that enables teacher collaboration within and across grade levels is critical to implementation fidelity.** These districts realized that the full benefits of a vertically aligned curricular framework is contingent on teachers having a thorough understanding of the foundational content and prerequisite skills of algebra, both for the grades they teach and for adjacent grades. However, building such understanding takes time and support. Providing intensive formal training in new content standards and aligned materials, and ongoing job-embedded professional development opportunities such as school-based or district-sponsored professional learning community (PLC) meetings that allow teachers to collaborate and share instructional strategies related to the new standards is essential to realize the benefits of a vertically aligned curricular framework. Although difficult to schedule, providing opportunities for teachers to collaborate not just with their grade-level colleagues, but teachers in the grades vertically below and above, may be particularly advantageous in promoting high quality and consistent implementation of the framework throughout the K–12 continuum.

- **Tools and resources that explain and sequence algebraic concepts across grade levels help teachers understand what needs to be taught and when.** As part of and in addition to ongoing professional development opportunities, teachers need access to scope and sequence documents, lesson activities, and performance rubrics that clearly convey what students need to know from grade to grade. These tools are most useful when they explicitly show how grade-level content is connected to what students learned in prior grades and how it will be built upon in subsequent grades.

- **Gaining the full buy-in of administrators and teachers is challenging and takes time, but instructional leaders can support their peers.** District leaders acknowledged that buy-in among school administrators and teachers for the vertically aligned curricular framework varied. Some school administrators and teachers, particularly those who had experienced "success" in terms of standardized assessment performance metrics, were initially reluctant to change pedagogical practices. Rhodes County and Parsons City addressed this challenge through the work of math coaches and teacher leaders who provided professional development and served as models and mentors to their peers.

3 Rhodes County at a Glance

Rhodes County at a Glance

Rhodes County is a rural, geographically large district that serves approximately 25,000 students in more than 40 schools. The district is divided into "subdistricts" and each subdistrict serves a single high school into which the closest proximity elementary and middle schools feed. This structure helps provide a greater sense of neighborhood and school community within this remote and mountainous district.

Table 1: Rhodes County at a Glance

Geographic Region	South Atlantic
Setting	Rural
District Enrollment	Approximately 25,000
Total Number of Schools	43
Number of Elementary Schools	22
Number of Middle Schools	11
Number of High Schools	9
High School Enrollment	Approximately 7,800
Algebra I Curriculum	Integrated, conceptual commercial program
K–8 Curricula	Conceptual, inquiry-based commercial programs (K–5 and 6–8)
Percentage Proficient Algebra I	77 percent
High School Attendance	Approximately 7,600
High School Graduation Rate	80 percent
High School Mathematics Teachers	77
Students Eligible for Free or Reduced-Price Lunch	Approximately 55 percent

All data were gathered from the district website and are representative of the 2012–13 school year, with the exception of high school attendance and the number of high school mathematics teachers. High school attendance and high school mathematics teacher data were provided by the district central office and are representative of the 2015–16 school year.

The majority population in Rhodes County is White and more than half of the county's students are eligible for free or reduced-price lunch. Fewer than 10 percent of students are classified as English learners (ELs), and close to 15 percent of students have Individualized Education Programs (IEPs). Teacher turnover is low, although due to retirements, new teachers come into the district every year.

Although Rhodes County did not adopt a K–12 vertically aligned curricular framework districtwide until the state's adoption of new academic content standards in 2010, the district's K–12 curriculum specialist, Mr. Johnson, was an early proponent of using instructional materials that build students' foundational algebraic skills in the elementary and middle school grades. He started introducing the use of these materials in some of the district's schools when he came to Rhodes County in the late 1980s. Prior to coming to the district, Mr. Johnson had served in a district that was connected to the local university's research community that was doing innovative work around mathematics instruction. He became involved in National Science Foundation research grants that were testing new mathematics instructional materials that were designed to promote the foundations of algebra. These experiences led him to seek out grant funding for similar opportunities when he started in Rhodes County and some of the schools became test sites for piloting new mathematics instructional

materials that focused on vertical alignment, including those associated with supporting the National Council of Teachers of Mathematics' (NCTM) process standards (NCTM, 2000). The NCTM process standards emphasized mathematical reasoning, problem solving, and communication across vertical grade levels to promote success in algebra and guided Mr. Johnson's work with schools and math teachers in the district until the state's official adoption of new challenging academic content standards in 2010. Largely a result of his vision and proactive approach to using non-traditional approaches to math instruction that were in early stages of design and development, Rhodes County is often viewed as a state leader implementing innovative approaches to mathematics instruction. In 2012–13, Grades 3–8 students in this district performed better than the state averages in mathematics.

Figure 1. Implementation Support Tools Used In Rhodes County

Year at a Glance. This tool provides an overview of a grade-level curriculum and serves as a high-level pacing guide for K-12 teachers. Each grade-specific tool is organized into a table outlining the units covered in each quarter of the school year, the name and focus of the units that fall within each quarter, the suggested time frame for covering each unit, and the state standards that are addressed in each unit.

Curriculum Map. Grade-level curriculum maps provide teachers with a comprehensive outline for each academic unit. Each map presents the "essential question" being asked by the unit (e.g., for a Grade 5 unit: "What patterns do we notice when we multiply and divide decimal numbers?"), important vocabulary for students to learn, student learning objectives (i.e., what students should be able to do at the end of the unit), and the standards that are covered by the unit. The maps also include detailed notes to teachers, including what strategies and content to revisit with students, what other tools to reference, and how to structure specific lesson plans and learning activities.

Unpacking Document. Unpacking documents are grade-specific, state-developed tools meant to support teachers' understanding of what each math standard covered at their grade level indicates a student must know, understand, and be able to do. The tool "unpacks" each standard by explaining the focus of the standard; describing in detail what mastery of the standard looks like, including examples of student work; and providing descriptions of the strategies students at the grade level are developmentally expected to use to solve a problem.

As earlier noted, in 2010, the state officially adopted new academic content standards that included challenging content and practice standards. The content standards reflect a vertically aligned curricular framework in which topics progress within and across grades, and algebraic thinking is a common thread throughout Grades K–8. The practice standards refer to the kinds of learning opportunities and habits of mind students are expected to develop as they learn the content. These practices include making sense of and persevering in solving problems, constructing viable arguments and critiquing the reasoning of other students, and using appropriate tools. Following its adoption of these new standards, the state provided additional resources and funding to Rhodes and other districts to support implementation. According to district leaders and teachers, Rhodes' previous work using textbooks and instructional materials that promoted algebraic skills in the early and middle grades, coupled with these additional resources from the state, helped smooth the districtwide transition to using a standards-aligned vertical curriculum to promote student success in algebra. Mr. Johnson explained:

> We had been telling teachers good ways for students to do math, but once the [academic content] standards came out, what we had been saying was in writing. We could point out exactly how kids could be doing algebra and it allowed us to build a foundation. Now our algebra domain is aligned with the standards and it encourages teachers to teach in that way.

With the influx of funding from the state to support implementation of the new academic content standards, Mr. Johnson also was able to expand his district team of support staff. He identified and recruited teachers who had demonstrated proficiency with the vertically aligned framework to serve as district-level math coaches. The district hired three coaches who had previously demonstrated leadership and commitment to using vertically aligned math curricular materials in the district to support teachers at the elementary, middle, and high school levels. Early in the implementation process, the coaches provided all K–5 teachers in the district with professional development in the new academic content standards domain of operations and algebraic thinking. High school teachers received training in the new textbook the district was using to anchor the Algebra I and subsequent high school mathematics curriculum. On an ongoing basis, the coaches work with Mr. Johnson and other curriculum and instruction district leaders to develop and refine standards-aligned tools including grade-level year-at-a-glance guides and curriculum maps that help teachers pace their instruction, design lessons, and understand how skills build vertically from one grade and one unit to the next. These leaders also support teachers' use of other tools and resources, including state-developed math standards "unpacking documents." (How these tools are used is described in more detail in the Implementation of a Vertically Aligned Curricular Framework section of this profile.) The coaches also lead regular professional learning community (PLC) meetings with school-based teams of mathematics teachers, and provide differentiated levels of support to individual schools and teachers based on their comfort and adeptness of implementation. According to respondents, Mr. Johnson's "hand-picked" approach to building a team of district math coaches has been a key factor in promoting district-wide implementation of the vertically aligned curricular framework.

4 Parsons City School District at a Glance

Parsons City School District at a Glance

Table 2. Parsons City School District at a Glance

Geographic Region	West
Setting	Urban
District Enrollment	Approximately 100,000
Total Number of Schools	199
Number of Early Childhood Education (ECE)*–K	3
Number of Elementary Schools	93
Number of ECE–8 Schools	18
Number of ECE–12 Schools	4
Number of Middle Schools	28
Number of Grades 6–12 Schools	14
Number of High Schools	39
High School Enrollment	Approximately 21,500
Algebra I Curriculum	Integrated, conceptual commercial program
K–8 Curricula	Conceptual, inquiry-based commercial programs (K–5 and 6–8)
Percentage Proficient in Algebra I	46 percent
High School Attendance	Approximately 21,300
High School Graduation Rate	65 percent
High School Mathematics Teachers	285
Students Eligible for Free or Reduced-Price Lunch	Approximately 69 percent

All data were gathered from the district website and from direct communication with the district mathematics leader. All data are representative of the 2015–16 school year, with the exception of percentage proficient in Algebra I and high school graduation rate. These data are representative of the 2014–15 school year.

Parsons City School District is a large, diverse urban district that includes nearly 200 schools. It is one of the fastest growing urban centers in the nation and operates a variety of types of schools, including traditional public schools, as well as magnet, charter, and other alternative pathways schools. Parsons City is organized into networks of schools, with each network led by a relatively autonomous superintendent.

The district serves nearly 100,000 students, the majority of whom are racial/ethnic minorities. Nearly 60 percent of the students are Hispanic, approximately 40 percent are ELs (mostly Spanish speaking), and almost 70 percent qualify for free or reduced-priced lunch. The district is committed to its EL population and all instructional materials are developed in English and Spanish. Parsons also has a history of seeking out partnerships with professional associations, other districts, and educational organizations to promote school improvement and innovation for its educators and students.

Parsons City has a robust central office infrastructure, including leadership and resources designated to support mathematics instruction specifically. The district has benefited from the work and vision of a long-standing and stable district math leader. Ms. Thomas has been with the district for more than 25 years, 10 of which as the district's mathematics and science director. Throughout her tenure in the district, she has promoted the early introduction of concepts and skills that are foundational for algebra. Her work was heavily influenced by guidance from the National Council of Teachers of Mathematics (NCTM, 2000, 2006).

Figure 2. Parsons City Teacher Leaders

- Are selected through an application process and evidence of effectiveness in the classroom.
- Attend summer Teacher Leader Academy.
- Meet regularly with district leaders for ongoing professional development and training to provide feedback on and refine instructional support tools to guide implementation of the curricular framework.
- Turnkey job-embedded professional development and serve as a mentor and resource to teachers at their schools.
- Spend half the day teaching and half the day providing coaching to teachers in their schools.

Parsons City's state revised its academic content standards in 2010 to include a more vertically aligned framework for the K–12 curriculum. The vertical alignment of algebraic thinking in the revised academic content standards for the state was consistent with Ms. Thomas's philosophy and the approach to mathematics instruction she had been promoting in the district. As a result, the district was relatively well positioned to transition to using the state's revised standards, although the district still recognized the need for a phased approach to implementation as teachers had to learn new scope and sequences for their grade levels and pedagogical approaches.

Ms. Thomas described Parsons City as having a strong commitment to distributed leadership given the size of the district. The district provides intensive supports to designated school-based teacher leaders and relies on these leaders to promote optimal implementation of curriculum and instruction at their schools. For example, since the adoption of the revised academic content standards, the district has organized a summer teacher leader academy. A cohort of teachers from each school in the district is invited to attend the academy and to serve as official teacher leaders at their respective schools. In the first years following the state's adoption of the revised academic content standards, the district focused the teacher leader academies on mathematics instruction and the vertically aligned framework. Ms. Thomas described, "In the first year, the academy focused on building teacher leaders' understanding of the academic content standards and then in the second year we did a lot of work around the mathematics practice [standards], but tied to rigorous [instructional] tasks." The third academy focused on the content standards, including what mastery of a standard looked like across the vertical grade levels. Teacher leaders who attend the academy are responsible for sharing information with the teachers at their home schools.

In addition to attending the teacher leader academy and providing job-embedded support and resources to teachers in their schools, teacher leaders work closely with the district to develop and refine the scope and sequence for all grades on an annual basis. In the initial development of the scope and sequence, teacher leaders analyzed the district-sponsored textbook series and identified external resources to address gaps between the textbooks and the new expectations for learning that accompanied the change in standards and accompanying assessments. According to Ms. Thomas and Parsons City teachers, the mathematics teacher leaders have been critical supports and play a key role in supporting the district's efforts to create tools and resources that promote consistent implementation of the vertical framework.

Figure 3. Implementation Support Tools Used In Parsons City

Scope and Sequence Standards Trajectory. This grade-specific tool provides a comprehensive outline of a particular unit of study, including its suggested length, a description of the unit focus, the standards and key concepts covered, student procedural skill and application expectations, and inquiry questions teachers can use to spark student interest and help guide students from factual to conceptual understanding.

Unit Overview. The math unit overview provides teachers with a high-level summary of key features of a specific instructional unit. The tool outlines the core lessons covered in the unit, the essential learning goals for students, the standards that are addressed, and instructional tips for ensuring focus, coherence, and rigor.

Formative Unit Assessment. These assessment tools are intended to inform teacher planning and to support their study and understanding of a unit by providing concrete examples of what students should know, understand, and be able to do after each unit. Each assessment is accompanied by a rubric that provides examples of the responses students below, at, or above the expected learning goal would provide for each question.

The district also annually reviews and refines the other tools they provide to teachers to support their implementation of the framework based on teacher leaders' and classroom teachers' feedback. These tools are described in more detail in the Implementation of a Vertically Aligned Mathematics Curriculum section.

5 Why Districts Turned to a Vertically Aligned Curriculum

Why Districts Turned to a Vertically Aligned Curriculum

Both Rhodes County and Parson City's focus on implementing a vertically aligned curriculum resulted from the efforts of district leaders who were on the cutting edge of curricular and mathematics standards reform movements. These leaders observed achievement gaps between students that they believed curricular reform could help close. Mr. Johnson and Ms. Thomas also reported seeing a vertically aligned curricular framework as a mechanism for addressing the unique needs of their student populations, including a high-mobility population in Rhodes and a racially, ethnically, and linguistically diverse population in Parsons.

In Parsons City, Ms. Thomas described her role in both state-level and district-level efforts to implement rigorous academic standards that promote student success throughout the K–12 continuum. In 2009, the state adopted a new set of vertically aligned academic standards that emphasized building students' foundational skills for success in algebra. In 2010, the state engaged Ms. Thomas and several others in the district who were recognized for their expertise to work with them to incorporate the academic content standards framework into the state academic standards to ensure consistency and alignment. These new academic content standards were adopted and rolled out in the district in 2010. According to Ms. Thomas and teachers in the district, the academic content standards helped further focus the state's standards and Parson's curricular framework on key mathematical practices, skills, and content that develop students' readiness for algebra across grades. The district also is a member of a large network of districts dedicated to sharing resources and learning from one another as they work to implement the academic content standards–aligned mathematics standards. Ms. Thomas described this network as an important network of support, as districts share resources and lessons learned as new knowledge and experience in using the academic content standards are gained.

Ms. Thomas and others in Parsons City described the vertically aligned curriculum as a critical tool for improving mathematics achievement among the district's diverse learners by promoting consistency of instruction across grade levels. The framework outlines for teachers what "proficiency" in a certain skill looks like not only at their grade level but also at the previous and subsequent grade levels. This allows teachers to focus their instruction accordingly. For example, teachers can build more effectively on the foundational knowledge they know students were exposed to in earlier grades and better support students' preparation for what they are expected to learn in subsequent grades. One middle school teacher explained, at the grade levels 6–8, the curriculum emphasizes patterns and moving from the concrete to abstract reasoning.

In Rhodes County, Mr. Johnson's involvement in the early research and curricular development efforts by NCTM (NCTM, 1980, 1991, 2000) to reform mathematics instruction shaped his vision for mathematics instruction well before the state's adoption of the new academic content standards in 2010. When Mr. Johnson came to Rhodes in the late 1980s, he started working with select schools and teachers at the elementary and middle school levels to develop and implement math textbooks and instructional materials that attended to the foundations of algebra critical to paving student pathways for success in Algebra I. Mr. Johnson and the other district leaders described how this commitment to building students' foundations for mathematics and algebra success in later grade levels has helped teachers, particularly elementary and middle school teachers transition to the new state standards. Likewise, high school teachers described how they became more directly engaged in understanding how early and middle grade preparation for algebra can affect students' success in Algebra I following the 2010 state adoption of the academic content standards. A high school teacher in this district stated:

> [Rhodes County] seems to do the best job [in the state] of aligning the curriculum in elementary and middle school to get them ready for [Algebra I]. When I taught at a different county and moved back, I could see how much better prepared the students were. The middle school teachers work hard and work with us to ensure students know what they need to know when they come to us. This helps me as a math teacher more than anything.

In addition, in Rhodes County, the consistency in curriculum addresses academic challenges associated with the high mobility of students among schools in the district. According to teachers, the year-at-a glance and standards-aligned curriculum maps help ensure teachers are following the same instruction and scope and sequence. This consistency supports students who move from one school to another. As the elementary mathematics coach explained, "Teachers are expected to teach the standards in the order listed and [they are] instructed to look at the standards as clusters [with any eye toward the] underlying ideas." For example, in the elementary grades, algebraic reasoning is emphasized to provide young students with early algebra foundations. Mr. Johnson also described a cross-vertical emphasis on developing students' mathematical practices, including their abilities to make sense of problems, construct plausible arguments, and critique others' arguments. This focus on mathematical practices is a common thread throughout the curriculum. These common threads across vertical grade levels serve to unite the framework and allow for a shared understanding, language, and approach to mathematics teaching and learning among school leaders, teachers, and students.

Respondents in both districts emphasized that tools like these are critical for the benefits of a vertically aligned curriculum to be realized. The adoption of standards that are designed to ensure vertical alignment, coherence, and rigor will not guarantee student success in Algebra I. Teachers must understand what the standards are and how to teach them.

6 Key Features of a Vertically Aligned Curriculum

Key Features of a Vertically Aligned Curriculum

Both sites introduce foundational concept and skill building in algebraic thinking in kindergarten and reinforce the skills in subsequent grades. In Algebra I, instruction builds off the foundational algebraic skills and concepts that students have learned in earlier grades. Elementary, middle school, and high school Algebra I teachers in both Rhodes County and Parsons City described instruction that reflected these key features of a vertically aligned curriculum.

Figure 4. Example Of Algebraic Thinking In Elementary Grades

Rather than asking students to simply multiply or divide two numbers (e.g., 5 × 4 or 20 ÷ 5), one third-grade teacher assesses multiplication and division in the context of solving an equation:

$n \times 5 = 20$, solve for n.

This approach has the dual benefit of assessing students' multiplication and division skills and evaluating their understanding of the algebraic concepts of variable and equality.

Elementary grade teachers described weaving algebraic thinking into the teaching of traditional arithmetic topics. In Parsons City, teachers talked about their mathematics instruction in the early grades as "laying the foundation" for students to be successful in Algebra I, often through topics familiar to students. For example, many students see the equals sign as an operator rather than as a symbol for equality. To address this misconception, teachers in Parsons City have moved from "just doing addition and subtraction" to having students solve for unknown values in these situations. One third-grade teacher described a recent unit test that included the question: $n \times 5 = 20$, solve for n. She intentionally framed this question as an equation to be "solved" rather than as an answer or fact to be generated. Another teacher said she took a similar approach, presenting students with missing numbers in equations to help address the misconception that the equal sign is simply an operator. The teachers also said that teaching algebraic thinking within the context of traditional arithmetic lessons made the material more interesting to teach. They described using open-ended questioning techniques and highlighting multiple entry points for students to solve a given equation. They said these strategies, which are consistent with the academic content standards practice standards adopted in both states, encourage flexible problem solving and show students that they are not "stuck doing things one way using one procedure."

Teachers in Rhodes County reported similar types of instructional practices in the elementary grades. For example, the second-grade curriculum introduces students to the idea of unknown values and a developmentally appropriate vocabulary

that young children can use to describe an unknown. One teacher explained how she uses a word for an unknown to help students "get the idea that there is a piece missing and the [missing] piece is not always the end result [of the problem]." A fourth-grade teacher described how they use this foundational knowledge to introduce students to using a letter for an unknown value in an equation. This vertical approach to building students' understanding of algebraic concepts helps students begin to distinguish expressions from equations in the early grades.

Middle school teachers emphasized bridging concrete and abstract thinking and promoting mathematical practices to prepare students for Algebra I. Middle school teachers in Rhodes County talked about how the vertically aligned curriculum provides a more coherent approach to mathematics instruction and to ensuring all students are being prepared to understand the concepts and practices introduced in Algebra I. As one teacher stated, "We have more coherence in algebraic thinking through middle school. Before, it didn't logically flow…now [teachers and students]…have all the common reference points." Another teacher explained that the sixth-grade curriculum uses instructional investigations with patterns to help students understand the meaning of variables, constants, and functions through tables and graphs. Although challenging, tasks that require students to identify patterns and make generalizations support developing a deep understanding of these interconnected concepts. These tasks also promote the habits of mind that are needed to succeed in Algebra I and beyond. As discussed earlier, these habits include making sense of problems, constructing plausible arguments, and critiquing the reasoning of others. Middle school classrooms have posters listing these and other critical mathematical practices and teachers described referring students to them frequently. For example, one teacher described that, before approaching a problem, she reviews this list of practices with her students to encourage them to take the steps necessary for persevering through a difficult task toward a solution.

In describing the value of teaching mathematical practices, one teacher remarked, "We are creating stronger and more flexible thinkers. The thinking aspect and not being afraid to try is a huge part of it."

Like in Rhodes County, middle school teachers in Parsons City described how they use district-developed instructional tasks to promote these habits of mind. These multiday tasks are designed as group projects that promote student persistence, collaboration, critical thinking, and justification of proposed solutions. A high school teacher in Parsons City emphasized the importance of students' being able to approach learning this way, particularly students' ability to persist when faced with difficult concepts. In Algebra I, for example, students are routinely presented with problems for which the answer is not immediately apparent.

Algebra I teachers in both districts observed positive changes in their incoming students' knowledge of algebraic concepts and some prerequisite skills. Parsons City high school teachers perceived that the vertical framework helped prepare more of their students for Algebra I. For example, Parsons City teachers indicated that

incoming students seemed more comfortable working with integers, important prerequisite skills for Algebra I (National Mathematics Advisory Panel, 2008). In addition, although this cannot be fully attributed to the framework, teachers observed that, after the vertically aligned curriculum had been in place, a greater proportion of incoming Algebra I students could solve for an unknown using inverse operations, complete basic work with functions, and demonstrate understanding of linearity. At the same time, teachers emphasized that fractions, another important prerequisite for success in Algebra I, remain a challenge for many students.

Similarly, in Rhodes County, high school teachers said that their incoming Algebra I students were more familiar with algebraic concepts. The teachers also noted that many students had been exposed to advanced algebraic ideas in elementary and middle school. As one teacher said, "Freshmen know about exponential growth and quadratic equations now; they would not have known this years ago."

7 Implementation of a Vertically Aligned Mathematics Curriculum

Implementation of a Vertically Aligned Mathematics Curriculum

When asked to describe the key features of a well-implemented, vertically aligned curriculum, district math leaders and teachers in both districts emphasized the importance of the following:

- An intentionally sequenced and phased rollout of the framework;
- Professional development opportunities for teacher collaboration within and across vertical grade levels; and
- Development and ongoing refinement of tools to support implementation.

District leaders described a phased, multistep approach to implementation. Rhodes County and Parsons City district leaders described a gradual, iterative approach to implementation of the vertically aligned framework.

As briefly discussed, when Mr. Johnson brought his vision for a vertically aligned curriculum to Rhodes County in the late 1980s, he first targeted select elementary schools. He then expanded implementation to other elementary schools, working primarily in schools with strong buy-in and demonstrated capacity. The adoption of the academic content standards in 2010 helped expand the work of the county because the state provided additional resources and funding for teacher professional development to support a systemwide adoption of a vertically aligned framework.

The state's adoption of the new academic content standards also mandated the implementation of a vertically aligned framework in all schools and all classrooms in Rhodes County. The state's previous standards did not emphasize or require teachers to use a curriculum that provided all students with the foundational skills needed for Algebra I. Algebra was primarily reserved for select groups of students who had demonstrated mathematics proficiency in earlier grades. The state's adoption of the academic content standards required that all students be taught skills that would prepare them for Algebra, beginning at an early age. According to a high school teacher, "Moving to [the academic content standards] opened a lot of doors because it forced everyone to think of things in a different way." As one of the math leaders explained:

> Previously, district support and implementation of the curricular framework had focused on a limited number of classrooms and schools where there was strong leadership and sufficient capacity for high-fidelity implementation.

A high school department chair, on the benefit of vertical grade collaborations: "We go from [grade-level] team to [grade-level] team, below and above, to let the folks below know what we need and to learn from the folks above what they need from us. We keep tabs on where kids are, what is being taught, what needs to be taught in eighth grade to support what kids need in ninth grade and moving forward."

In Parsons City, the official adoption of the revised academic content standards in 2010 encouraged the district to examine the coherency of its curricular framework across grade levels to ensure all students are prepared for Algebra I. As discussed, in conjunction with the state's adoption of the academic content standards, Parsons City took a proactive stance to ensuring their curricular framework was vertically aligned. Ms. Thomas described how district leaders, along with groups of elementary, middle, and high school teachers, took a careful look at the standards alongside the framework with the following question in mind: "Are we building the basis at each grade level, and have we written [the framework] in a way that makes that alignment transparent?"

Although prior to the 2010 revision of the state academic content standards, the district had used a K–12 framework that emphasized number sense, algebraic thinking, data and statistics, and geometry, the academic content standards had an even greater focus on building students' foundational algebraic skills. To enhance teachers' capacity to implement the new approaches to mathematics pedagogy and content that an academic content standards–aligned framework required, the district decided on a three-year phased implementation process. First, the district focused on building teacher understanding of the framework and the academic content standards. The following year, the district trained teachers in the mathematical practices standards. The district concentrated the third year of implementation on developing teachers' understanding of the revised content standards. Teachers in Parsons appreciated this gradual, multiyear approach to change. As one teacher said:

> The nice thing about [this district] is that we had bridging time to get into this new type of instruction and the new materials. [Parsons City] is on the right track; they didn't throw everything onto us all at once. They did a good job of rolling everything out. They've helped us transition into the new work coming in.

In addition, a specific rollout strategy that Parsons found effective was the use of high-leverage instructional tasks, which were mentioned previously. These group tasks, which can take a few days to implement, model the shifts in content and practice espoused by the academic content standards. The district started small—one task per semester for Grades K–12 in the first year—and then added more tasks and accompanying resources, including content-focused professional development, in subsequent years. These phased-in tasks also helped teachers and students transition to the rigor of the new standards and the philosophy guiding the vertical framework.

District leaders highlighted the importance of providing intensive and ongoing professional development to teachers as they rolled out vertically aligned frameworks. Both districts provided teachers with professional development activities to support implementation of their vertically aligned frameworks. In Rhodes County, district math leaders and coaches described a formal, job-embedded professional development model that focused on developing teachers' understanding of algebraic concepts and prerequisite skills, with an emphasis on how these concepts and skills are developed across vertical grade bands. As one district coach explained:

> We remind high school teachers that approaches used at middle and elementary school levels are still relevant by showing how a particular model is used throughout the grade levels. For example, the area model is one valid way to allow students to access their prior knowledge to see how it works in algebra. We…work with the teams from elementary and middle schools to discuss how the mathematics connects at different levels…. We show what it looks like in the [middle school] textbook and connect it to high school teaching. This allows teachers to remind their students of what students have done in other grades.

Initially, in rolling out this type of professional development to teachers in Rhodes, the district began by providing all K–5 teachers and select teams of middle and high school teachers with opportunities to collaborate and discuss how topics are developed within and across grades. They later provided teachers opportunities to delve more deeply into the content, particularly topics that were new to their grade level or topics for which they had not received as much formal training (this was more the case for elementary teachers, who tend to be generalists rather than content experts).

District coaches in Rhodes facilitated the formal professional development activities, including collaborative planning time, which the teachers found valuable. To facilitate the planning and execution of lessons that promote deep understanding of key concepts in their framework, the district started implementing a "studio" program modeled after the principles of Japanese Lesson Study (Lewis, Perry, & Hurd, 2004). In the program, teachers within a grade band (e.g., Grades K–2 or Grades 6–8) (1) review a lesson plan, (2) anticipate what students will do, (3) complete the mathematics lesson as a group, (4) observe a teacher deliver the lesson, and (5) debrief the process as a group. District coaches led the rollout of mathematics studios in the first year, and many schools have been running them independently since then.

Parsons City also uses a distributed leadership model. Rather than using district-level coaches, they use mathematics teacher leaders from each school who were trained through teacher leader academies, as previously explained. These teacher leaders collaborate with the district in the development and refinement of tools to support implementation of the vertical framework, which they also share through school-based PLCs and their one-on-one work with teachers.

A Rhodes County district math coach explained, "I work with the staff to help them think about the next chunk of instruction and then look at what standards are being taught.... We then go to the [curriculum maps] to see what it looks like day by day through the lens of the standards."

Both districts developed tools and resources to support teachers' understanding and enactment of their vertically aligned frameworks. In Rhodes County, the tools included grade-level Year-at-a-Glance unit pacing guides that map to specific standards; grade-level "unpacking documents" that describe what students will know, understand, and be able to do; and unit-specific curriculum maps that outline key lesson activities, including which standards in the framework are covered and standards-based student learning targets. The learning targets in Rhodes are commonly described as student "I can" statements that help both teachers and students understand what students should be able to do at the end of each unit. For example, first-grade "I can" statements that are linked to a unit on solving story problems include "I can solve problems where a part is unknown" and "I can use the correct symbols (+ and =) to show a combining situation."

Table 3. Unpacking Content Standards Resource

Third-Grade Content Standard	Unpacking the Standard
Solve two-step word problems using the four operations. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. *This standard is limited to problems posed with whole number answers.*	**Context** • Students are beginning to make the transition from the symbols of arithmetic (+ , – , × , ÷) to the symbols of algebra (variables). • The size of the numbers should be appropriate for third grade. o + / - within 1,000 o × / ÷ single-digit factors and products less than 100 **Example** Tim has 5 boxes of candy. Each box has 7 pieces of candy in it. Mary has 16 fewer pieces of candy than Tim. How many does she have? Tim: 7 7 7 7 7 Mary: M 16 T = Number of pieces of Tim's candy M = Number of pieces of Mary's candy T = 5 × 7 = 35 M + 16 = T M + 16 = 35 M = 19 *Have students estimate first* *Use letters that match the problem*

Parsons City also used grade-level scope and sequence standards trajectory documents to support implementation of the framework. These scope and sequence standards trajectory documents break the mathematics standards into units within the context of grade-level pacing guides and support teachers in helping their students move from factual to conceptual understanding. The district also provides teachers with unit overviews that provide a high-level summary of the instructional focus, the student learning goals, and instructional strategies for teachers to guide their practice. In addition, Parsons City, working with the mathematics teacher leaders, developed formative unit assessments with associated rubrics to help teachers better understand the expected proficiency level and what demonstration of mastery looks like. These types of tools were described by teachers as foundational resources that help "bring to life" what the standards related to algebraic thinking and mathematical practices look like in classroom teaching and student learning.

Table 4. Scope and Sequence Standards Tool for Teachers (Solving and Writing Linear Equations)

Guiding Questions to Build Conceptual Understanding		
My students understand that...	Factual	Conceptual
• Creating equivalent algebraic equations provides the necessary foundation for solving linear equations in one variable (A-REI.1)	• What is an example of a one-variable linear equation with no solution? What is an example of a one-variable linear equation with an infinite number of solutions? • How does creating equivalent expressions lead to solving one-variable linear equations?	• How can one-variable equations have no solutions or an infinite number of solutions? • How does problem context affect solutions' reasonableness?
• How does problem context affect solutions' reasonableness?	• Which representation can be used to represent linear relationships? • How does the context of linear relationships help interpret linear functions' rates of change and initial values? • How can graphs, tables, and questions be used to determine rates of change and initial values?	• Why do we show relationships using different representations?

The new teacher evaluation system in Parsons City also supports implementation of a vertically aligned curricular framework. As part of the process, teachers work with teacher leaders to develop and choose two SLOs that are focused on key standards being taught, identify expectations for student growth on critical learning outcomes related to those standards based on baseline data, and build a performance rubric to monitor and measure growth. In determining their SLOs, teachers look at what proficiency means in the prior and following grades, often talking to their colleagues in lower and upper grades to ensure their understanding. A high school department chair described how teachers collaborate with each other as part of the SLO development process as follows:

> We go from [grade-level] team to [grade-level] team, below and above, to let the folks below know what we need and to learn from the folks above what they need from us. We keep tabs on where kids are, what is being taught, what needs to be taught in 8th grade to support what kids need in 9th grade and moving forward.

The teachers in the district remarked that a clear understanding of the math standards in adjacent grades helps deepen their understanding of what their students need to master and be prepared to learn by the end of the school year. In this way the SLO system in itself strengthens their knowledge of the vertical framework.

Table 5. SLO Development Tool for Teachers (Grade 7 Unit Rate Example)

Standards for the grade levels and content areas before your grade level	Standards and content areas for your grade level	Standards for the grade levels and content areas after your grade level
Ratios and Proportional Relationships: *Understand ratio concepts and use ratio reasoning to solve problems.*	Ratios and Proportional Relationships: *Analyze proportional relationships and use them to solve real-world problems.*	Expressions and Equations: *Understand the connections across proportional relationships, lines, and linear equations*
• Understand the concept of a unit rate a/b associated with the ratio a:b and b≠ 0.	• Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units	• Graph proportional relationships, interpreting the unit rate as the slope of the graph.

Educators from both districts described their curricular framework tools as "living documents." District and school leaders in both sites solicited feedback from teachers throughout the year and formed working groups over the summer to refine and revise the tools and resources to better support implementation in the following school year. This iterative improvement process is less formal in Rhodes County in which officials relay on informal communications between teachers and the district coaches. In Parsons City, the district sends out a formal survey to teachers requesting feedback on the scope and sequence and other tools, which they use to guide the revisions they make each summer.

8 Challenges and Facilitating Factors

Challenges and Facilitating Factors

Securing time for vertical teacher collaboration across adjacent grade levels, and across the elementary, middle, and high schools is critical yet difficult to schedule. Teachers in both districts highlighted the value of dialogue among teachers across vertical grade levels, and, when possible across elementary, middle, and high schools. Teachers indicated that these opportunities to meet with teachers in the grades above and below them enhanced their understanding of the foundational skills students had developed in earlier grades, as well as what they needed to know to be ready for the next grade level and later grades. These opportunities were also important to district leaders, who used teachers' feedback on teachers' perceptions of the coherence of the framework to refine the tools and resources they developed to support implementation.

Figure 5. Recommendations From Rhodes County and Parsons City

- ✓ Time for teacher collaboration within and across vertical grade levels and grade bands is critical.
- ✓ Administrator and school-level buy in facilitates implementation of the framework and can be supported by the work of school-based teacher leaders who serve as models and peer mentors.
- ✓ Transparency and translating the guiding principles of the framework and rationale behind scope and sequence decisions can facilitate buy-in.
- ✓ Teachers need tools to guide implementation to ensure they build off prior years' instruction and prepare students for success in the next grade.
- ✓ Continued funding for targeted professional development in the vertical alignment of algebra skills and concepts can facilitate sustainability.

In both districts, cross-grade level meetings primarily occurred within individual schools and the grade bands represented in a school, but were not necessarily consistently in implementation or teacher participation across schools. Rhodes County had designated PLC times for mathematics teachers to come together. These PLCs were primarily teacher led but were being supported by the district's math coaches. According to the coaches, the frequency of PLCs varied among the schools, with some designating weekly or biweekly times during the school day and others holding larger monthly meetings on early release days. Some schools designated certain PLC meetings for vertical grade-level meetings. The district coaches also organized occasional cross-school math teacher meetings at the district office, but these are voluntary and the coaches reported that they were not always well attended, if not because of a lack of interest, but the time and effort for some teachers to travel to the district office or use their personal time to attend. Nevertheless, the teachers who attended these vertical grade-level meetings indicated they had a much stronger understanding of the vertical alignment than teachers in other schools.

In Parsons City, many of the teacher respondents in Grades 6–12 schools described having designated coplanning meetings among the full mathematics team that focused on vertical integration across all of these grades. At Grades 9–12 schools, similar meetings were held, according to some of the respondent teachers. The district leader and teachers, however, noted that not all schools hold these meetings consistently.

As discussed previously, Parsons City is divided into approximately 10 networks, each of which is led by a network superintendent. Although the central office oversees the work of the superintendents, these network leaders have autonomy over portions of their budget, including funding for teacher professional development. In Parsons City, some of the networks provided dedicated time and resources to support vertical grade band meetings among teachers, but not all networks did this. The interviewed teachers who were in networks that provided this time reported finding this model useful.

Gaining the immediate buy-in of school leadership and classroom teachers can be difficult to obtain, but data-driven conversations and ongoing professional development can help. District leaders, math coaches, and teachers leaders often have the greatest input on and knowledge of key decisions about the curriculum that affect schools' and teachers' practices. The math leaders in both Rhodes County and Parsons City indicated that some of the educators who are less familiar with the rationale for using a vertically aligned curriculum and the benefits of changing traditional approaches to math instruction were more resistant to using the framework; Rhodes County experienced this challenge at the principal and teacher levels. Parsons City teacher leaders described this challenge at the teacher level. As one teacher leader in Parsons City explained:

> There are few people who develop the scope and sequence, write the assessments, etc. The folks who do this, we have a more in-depth knowledge of the rationale behind the materials. That doesn't necessarily translate down to the rest of the teachers in the district.

The district coaches in Rhodes County described addressing these challenges by continuing to have conversations with school administrators, providing examples of success using the new approach in terms of teacher practices and observations of improved student learning. The coaches also review student-level data with administrators and teachers to highlight where gaps in learning exist and how new approaches to teaching and learning can help close achievement gaps between students and still advance the learning of high-performing students. The school-based mathematics teacher leaders in Parsons City described leading by example, and maintaining an open invitation for teachers to use them as a resource. They described this approach as helpful in pulling along even the most resistant teachers. For example, teacher leaders reported using early adopters in their schools to model lessons for the other teachers, thereby demonstrating the successes of using the vertically aligned curriculum in terms of teacher practices, student learning, and student engagement.

Resources to support teachers' understanding and implementation of vertically aligned curricula are difficult to sustain. Many of the facilitating factors for successful districtwide implementation of a vertically aligned curriculum require

ongoing funding and support. Both districts benefited from grants and other funding opportunities to provide professional development and support the development of instructional tools in the early years. Both districts, however, had difficulty sustaining funding. In Rhodes County, the intensive professional development for teachers to learn directly from curriculum developers and other external providers could not be sustained after certain grant funding cycles ended. The district has used the coaches to provide job-embedded training, but teachers missed the benefits of these external trainings in terms of their intensity and depth. In Parsons City, mathematics leaders indicated that central office leadership perceived that the mathematics curriculum and implementation of the vertically aligned framework was "further ahead" of reading/language arts. As a result, in recent years, they shifted funds for professional development away from mathematics. The continued leadership of Ms. Thomas has provided some sustainability in ensuring consistent implementation of the framework and support for new teachers. She, along with the school-based teacher leaders, continues to guide teachers in prioritizing instructional materials, revising and refining the tools and resources, and organizing PLCs and staff meetings to encourage teacher collaboration within and across vertical grade levels.

9 Key Considerations for Education Decision Makers

Key Considerations for Education Decision Makers

As you consider how best to implement a practice within your local context, it is important to consider the insights gained from a variety of sources. Table 6 highlights how key findings from a systematic literature review of curricular alignment (Smith, 2014a; see http://www2.ed.gov/programs/dropout/curricularalignment092414.pdf) and implications of those findings were reflected in the districts and schools profiled for this brief. As referenced previously, this project also includes a series of perspective briefs, one of which is focused on the topic of curricular alignment. This perspective brief highlights practitioners' reactions to the findings from the systematic literature review (Smith, 2016; see http://www2.ed.gov/programs/dropout/curricularalignmentperspectivebrief.pdf).

Table 6. Findings From Curricular Alignment Literature Review

The strongest vertically aligned curricular frameworks...	Curriculum developers or administrators should consider...	Was this reflected in Rhodes County and Parsons City?
Focus on skill and understanding of the critical foundations of algebra: • Whole numbers and whole number operations • Fractions and fraction operations • Similar triangles and solving for unknown values when working in the context of measurement	Ensuring curricular frameworks emphasize skill and understanding of the critical foundations of algebra prior to Algebra I.	The inclusion of skills and concepts that are critical foundations of algebra prior to Algebra I was a key factor in both districts' decisions to adopt their current curricular frameworks. The curricular framework helps ensure that these critical foundational skills are taught in accordance with the structure of mathematics and learning progressions. The framework also ensures coherence across the vertical grade levels leading up to Algebra I.
Expose students to algebraic concepts as an extension of arithmetic	Ensuring curricular frameworks expose students, prior to enrollment in Algebra I, to algebraic concepts as an extension of arithmetic.	The elementary teachers in both districts described teaching operations, fractions, and solving for unknown values. They also emphasized an instructional focus on teaching students to apply strategies flexibly in new contexts. Parsons City teachers described introducing students to the ideas of patterns and graphing patterns to develop students' algebraic thinking skills.
Sequence standards according to the structure of mathematics and learning progressions.	Ensuring that standards are sequenced across grade levels so that they are consistent with the structure of mathematics and what is known about learning progressions.	Rhodes County and Parsons City developed scope and sequence documents and standards-mapping documents that show the verticality of the standards across the grade levels, including examples of proficiency in a standard at each grade level. These documents outline how the algebraic skills teachers are teaching in one grade level build off what students learned in previous grades and how what they are learning in their current grade will inform what they will learn in more depth in subsequent grades.
Understand the vertical features of curricular frameworks.	Communicating the vertical nature of the standards to teachers, including mapping standards across grade bands, through professional development.	District math coaches in Rhodes County developed and refined tools and resources to support teachers' implementation of the framework in their classrooms. The district also provided intensive professional development to elementary- and middle-school teachers in the foundational skills needed for Algebra I and when and how to teach these skills. Parsons City trained school-based teacher leaders who are then tasked with supporting teachers' use of the tools and resources the district has developed. Teacher leaders collaborate closely with the district to refine tools based on feedback from the teachers.

10 Appendix

Appendix. Sampling, Data Collection, and Analytic Methods

In selecting sites for *Promoting Student Success in Algebra I,* the objective was to identify districts and schools that implemented activities associated with the five topical areas that are the focus of this project (instructional practices, professional development, instructional coaching, curricular alignment, and supplementary learning opportunities). In addition, for the practice profiles to be of greatest utility to practitioners and policymakers, we sought to identify sites that were implementing the practices identified in the research (see Research Briefs) as showing the strongest evidence of effectiveness. To enhance the probability that practitioners would identify with the school and district sites, we sought variation with regard to urbanicity, school size, and student demographics. Briefly, the selection criteria included the following:

- Criterion 1: Sites will represent exemplars.
- Criterion 2: Each site should provide some evidence of improved outcomes.
- Criterion 3: Sites will reflect geographic diversity.
- Criterion 4: Sites will reflect the diversity of enrolled students.

With regard to curricular alignment, our specific expectations were as follows:

Curricular alignment: Selected sites will be districts with an established curricular framework that is vertically aligned to prepare students for Algebra I. More specifically, this curricular framework should specify a series of standards that are vertically aligned to support students in the development of skills and understandings needed for Algebra I. These include, but are not limited to, an understanding of whole number and fraction operations and the ability to reason algebraically. The standards within the curricular framework should be clearly stated and organized to support a connected progression of skills and understandings that will ultimately prepare students for Algebra I.

Both sites profiled here provided evidence of improvement. In the 2012–13 school year, students in Grades 3–8 at Rhodes County performed better than the state averages in mathematics. At the other site, Parsons City School District, the district had experienced rising graduation rates, which includes the enrollment and completion of Algebra I and Algebra II based on

graduation requirements. In 2015, the district's graduation rate was approximately 65 percent,[4] an increase from just 52 percent[5] in 2010, prior to the full implementation of the academic content standards–aligned K–12 vertical framework.

Teams of at least three project staff visited each of the profiled sites following training in data collection procedures. On-site data collection activities included interviews, focus groups, observations of professional learning opportunities, document data collection, and informal classroom observations. The interview and observation protocols were developed by project staff with expertise in algebra content, research on math professional development, and qualitative research. Each protocol was piloted and refined based on feedback from practitioners before being fielded for this project. A total of 37 educators were interviewed across the two sites: 13 administrators and 6 teachers in Rhodes, and 5 administrators and 13 teachers in Parson City. All interviews and focus groups were audio-recorded and transcribed. Following the school and district visits, the project team immediately summarized their observations. These observations were used to identify initial themes and supported the development of codes.

Interview and focus group transcriptions were coded in a qualitative data analysis software package. Prior to coding, the project team developed a set of codes with associated definitions and trained staff for consistent application of codes. Additionally, a senior staff member reviewed the coded data as a quality control procedure. Coded data enabled the project team to retrieve data on common topics across interviews. For example, code retrieval allowed the team to analyze all the relevant data points on such topics such as district supports or teacher collaboration. The coding process ultimately allowed for the identification of prominent themes and informed the development of the Key Considerations.

[4] Based on data from the state education agency website.
[5] Based on data from the state education agency website.

11 References

References

Ham, S., & Walker, E. (1999). Getting to the right algebra: *The Equity 2000 initiative in Milwaukee Public Schools.* New York, NY: MDRC. Retrieved from http://www.mdrc.org/publications/98/workpaper.html

Helfand, D. (2006, January). A formula for failure in L.A. schools. *Los Angeles Times.* Retrieved from http://www.latimes.com/news/local/la-me-dropout30jan30,0,1678653.story

Hiebert, J., & Stigler, J. W. (2000, September). A proposal for improving classroom teaching: Lessons from the TIMSS video study. *Elementary School Journal, 101*(1), 3–20.

Lewis, C., Perry, R., & Hurd, J. (2004). A deeper look at lesson study. *Educational Leadership, 16*(5), 18–22.

National Center for Educational Statistics. (2015). *Public high school graduation rates.* Washington, DC: Institute of Education Sciences, National Center for Educational Statistics. Retrieved from http://nces.ed.gov/programs/coe/indicator_coi.asp

National Council of Teachers of Mathematics (NCTM). (1980). An agenda for action: *Recommendations for school mathematics of the 1980s.* Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (2006). *Curriculum focal points for prekindergarten through grade 8 mathematics: A quest for coherence.* Reston, VA: Author.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards Mathematics.* Washington, DC: Authors.

National Mathematics Advisory Panel. (2008). Foundations for success: *The final report of the national mathematics advisory panel.* Washington, DC: U.S. Department of Education.

Oriheula, Y. R. (2006). *Algebra I and other predictors of high school dropout* (Doctoral dissertation). Florida International University, Miami, FL. Retrieved from http://digitalcommons.fiu.edu/dissertations/AAI3249717

Schmidt, W. H., Wang, H. C., & McKnight, C. C. (2005). Curriculum coherence: An examination of U.S. mathematics and science content standards from an international perspective. *Journal of Curriculum Studies, 37*(5), 525–559.

Smith, T. S. (2014a). *Curricular alignment strategies to support student success in Algebra I: Research brief.* Washington, DC: U.S. Department of Education. Retrieved from https://www2.ed.gov/programs/dropout/curricularalignment092414.pdf

Smith, T. S. (2014b). *Instructional strategies to support student success in Algebra I: Research brief.* Washington, DC: U.S. Department of Education. Retrieved from https://www2.ed.gov/programs/dropout/instructionalpractices092414.pdf

Smith, T. S. (2016). *Student success in Algebra I through curricular alignment: Perspective brief.* Washington, DC: Office of Elementary and Secondary Education. Retrieved from https://www2.ed.gov/programs/dropout/curricularalignmentperspectivebrief.pdf

Sorensen, N. (2014). *Supplemental learning strategies to support student success in Algebra I: Research brief.* Washington, DC: U.S. Department of Education. Retrieved from https://www2.ed.gov/programs/dropout/learningsupports092414.pdf

Stoelinga, T., & Lynn, J. (2013). *Policy brief: Algebra and the underprepared learner.* Chicago, IL: Research on Urban Education Policy Initiative, University of Chicago. Retrieved from http://c-stemec.org/wp-content/uploads/2013/08/Algebra-and-Underprepared-Learner.pdf

Walters, K. (2014a). *Instructional coaching to support student success in Algebra I: Research brief.* Washington, DC: U.S. Department of Education. Retrieved from https://www2.ed.gov/programs/dropout/instructionalpractices092414.pdf

Walters, K. (2014b). *Professional development strategies to support student success in Algebra I: Research brief.* Washington, DC: U.S. Department of Education. Retrieved from https://www2.ed.gov/programs/dropout/professionaldevelop0914.pdf

AIR®
American Institutes for Research®

1000 Thomas Jefferson Street NW
Washington, DC 20007-3835
877.322.8700

www.air.org

This brief was produced under U.S. Department of Education Contract No. ED-ESE-12-0-0081 with American Institutes for Research. Ivonne Jaime served as the contracting officer's technical representative. The views expressed herein do not necessarily represent the positions or policies of the Department of Education. No official endorsement by the U.S. Department of Education of any product, commodity, service or enterprise mentioned in this publication is intended or should be inferred.