October 2017

Professional Development

Profile of Practice Brief

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1 Introduction

Introduction

High school graduation rates in the United States are at their highest in U.S. history—81 percent. Even so, nearly one in five students nationally does not graduate from high school and dropout rates are particularly high for students from low-income families, racial and ethnic minority students, 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 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

[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.

these discussions have been published in a series of perspective briefs. Third, the project includes profiles of practice that provide an in-depth look at implementation of these five strategies.

One of these five research-based strategies concerns professional development supports for algebra teachers. The PSSA project's research brief on this topic (Walters, 2014b; see https://www2.ed.gov/programs/dropout/professionaldevelop0914.pdf) indicated that algebra teachers benefit from concentrated time to deeply study the concepts they teach and how students think about and learn those concepts. The research review also suggested that the most promising professional development models were intensive, sustained, collaborative, and tightly linked to practice. These findings suggest that ongoing, job-embedded learning opportunities for teachers to talk about the content they teach and how students approach the content are promising. For some districts and schools, creating such job-embedded models may involve restructuring teachers' work weeks and work days.

This profile describes two high schools that have intentionally created and sustained intensive, job-embedded professional development models for their mathematics departments and, specifically, for their Algebra I teachers. Although the schools differ somewhat in terms of the focus of their professional development programs and how long they have been operating, both schools creatively restructured their respective work weeks to provide these learning opportunities for teachers. The goal of this profile is not to suggest that other schools and districts should mimic these approaches, but rather to share experiences and ideas that other schools and districts may adapt to meet their own students' needs.

The information presented here emerged from visits to two schools: McNair High School and Canyon Springs High School.[3] During these visits, AIR staff conducted interviews and focus groups with district mathematics leaders, mathematics coaches, school administrators, mathematics department chairs and mathematics teachers. AIR also reviewed documents describing the professional development programs at the two schools and their respective districts and conducted observations of professional development meetings and algebra lessons in both schools.

[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 schools profiled here.

- **Schools can creatively and inexpensively establish regular time for teachers to collaborate.** Both schools found ways for their algebra teachers to meet at least one hour per week as school-based professional learning communities by making modest adjustments to their bell schedules. By redistributing instructional minutes across the work week, both schools created the additional time needed for job-embedded collaboration at no extra cost.
- **Strong professional learning communities are guided by frameworks that articulate the big ideas of algebra and how students best learn those ideas.** Both school-based professional learning communities were organized around an essential set of algebraic concepts that anchored their respective algebra courses and teachers' collective learning. Both schools also had distinct pedagogical philosophies about how to maximize the number of students who are able to understand and apply these core ideas.
- **Analyzing common student data can productively guide professional learning communities.** Both school-based professional learning communities relied on student work and assessment data to guide their collaboration. At Canyon Springs High School, reviewing common assessment data allowed the school's learning community to successfully initiate its collective effort. At McNair, reviewing student assessment data, assessment items, and student work samples have been fundamental elements of the school's learning community during the past two decades.
- **Integrating preservice and inservice teacher training can produce a powerful, long-term professional development model.** McNair's mathematics department and the local university have a unique, synergistic relationship. During the past 25 years, university professors have cotaught courses and copublished articles with McNair teachers, while McNair teachers have provided internships for preservice teachers. This relationship has produced a multiyear apprenticeship for early career teachers and ongoing continuous improvement opportunities for more experienced teachers.
- **Strong, job-embedded models can stimulate informal teacher collaboration throughout and beyond the school day.** Algebra teachers at McNair view teaching as an intellectually stimulating craft to be continually honed. This is reflected not only in their formal collaborative meetings, but also in how regularly they interact with one another between classes, during lunch, and after school to discuss issues related to their teaching. There is a culture of curiosity and continuous improvement at McNair that runs throughout the mathematics department, inside and outside of classroom.

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Canyon Springs High School at a Glance

Canyon Springs High School is one of 16 high schools in a large, urban district in the Southwest. More than 70 different home languages are represented across the district, with less than 50 percent of the students identifying English as their primary home language.

Table 1: Canyon Springs High School at a Glance

Geographic Region	Southwest
Setting	Urban
District Enrollment	Approximately 28,000
Total Number of Schools	16
Number of High Schools	16
Canyon Springs High School Enrollment	Approximately 3,000
Canyon Springs High School, Percentage Proficient in Mathematics	54 percent
Canyon Springs High School Attendance Rate	93 percent
Canyon Springs High School Graduation Rate	80 percent
Number of High School Mathematics Teachers	23
Canyon Springs High Schools Students Eligible for Free or Reduced-Price Lunch	74 percent
Algebra I Curriculum	Commercial program

Data were provided by district administrators and are representative of the 2015–16 school year, with the exception of percentage proficient in mathematics and graduation rate, which were pulled from publicly available sources and representative of the 2013–14 school year. Values have been slightly modified from original values to protect the identity of the site.

Canyon Springs High School serves approximately 3,000 students from two feeder, partner districts. The majority of students are from diverse racial and ethnic backgrounds; a little over 65 percent of the student population identifies as Hispanic, and approximately 15 percent of the student population identifies as Black or African American. Nearly three in four students are eligible for free or reduced-price lunch. Canyon Springs has an expansive Advanced Placement program and prides itself on the success and growth of this program in recent years.

Similar to McNair High School, job-embedded professional development at Canyon Springs High School provides mathematics teachers with weekly meetings to collaborate as a department and as course-specific clusters. With the support of an outside consultant and the district mathematics specialist, Canyon Springs High School mathematics teachers have focused on developing common assessments and common grading criteria. The consultant was hired to help the district develop a structure for its high schools to launch professional learning communities, an initiative that involved analyzing common student data to shape the focus of the community's work. The consultant trained the mathematics specialist to continue this work after the external support concluded. This has enabled Canyon Springs High School to analyze student work and student data across classrooms. These efforts have informed school-wide decisions about course placement and prepared teachers to better define and understand the challenges and supports needed by struggling students to be successful in Algebra I.

4 McNair High School at a Glance

McNair High School at a Glance

McNair High School is a lively and welcoming school and is the only high school within its suburban district in the Midwest region. Most of the school's mathematics teachers are clustered together in accordance with their persistent requests, a means of organizing that creates a unique sense of camaraderie as teachers informally collaborate and make contact with one another between classes and during lunch.

Table 2. McNair County Schools at a Glance

Geographic Region	Midwest
Setting	Suburban
District Enrollment	Approximately 6,000
Total Number of Schools	10
Number of High Schools	1
McNair High School Enrollment	Approximately 2,000
McNair High School, Percentage Proficient in Mathematics	27 percent
McNair High School Attendance Rate	95 percent
McNair High School Graduation Rate	91 percent
Number of High School Mathematics Teachers	13
McNair High School Students Eligible for Free or Reduced-Price Lunch	33 percent
Algebra I Curriculum	School-created

Data were provided by district administrators and are representative of the 2015–16 school year, with the exception of percentage proficient in mathematics and graduation rate, which were pulled from publically available sources and representative of the 2013–14 school year. Values have been slightly modified from original values to protect the identity of the site.

The district serves nearly 6,000 students, the majority of whom are White. Roughly 10 percent of the student population identifies as Hispanic/Latino, and another 10 percent identifies as Black. McNair High School serves approximately 2,000 students, a third of whom are eligible for free or reduced-price lunch. As a result of a school choice program involving McNair and other high schools as part of an intermediate district, these student demographics are significantly more racially and ethnically diverse than was the case 15 years ago. An increasing number of students from more diverse areas have selected McNair because of its strong academic reputation.

McNair High School is less than 10 miles from a large public university. A majority of the mathematics teachers at McNair High School are graduates of the nearby university, completed their student teaching internships at McNair High School, and earned their undergraduate degrees from the university's College of Education. The collaborative nature of the McNair mathematics department and the professional learning environment cultivated by the department's chair makes McNair High School a desired place to teach, resulting in high teacher retention rates.

In the early 1990s, McNair High School formalized its partnership with the nearby university and became a professional development school.[4] Mathematics teachers cotaught high school courses with university faculty and engaged in frequent lesson study among other professional learning opportunities. Although its formal professional development school structure has ended (as has the funding source that supplemented it), the McNair High School mathematics department has sustained aspects of the work (e.g., collaborative lesson planning and collaborative development and reflection of common tasks and assessments) and continues to cultivate a culture of reflection, curiosity, and continuous improvement.

All McNair High School staff continue to participate in job-embedded professional development every Wednesday morning. Once or twice each month, teachers use this time to meet as departments. The mathematics department chair intentionally uses this time for both department-wide and course-specific collaboration. He fills the agenda with rich activities meant to spark meaningful and relevant discussions on the teaching and learning of mathematics, such as analyzing student work samples, grading common assessments, and reading and discussing research articles related to mathematics education. The mathematics department has an atmosphere of strong, professional collaboration.

[4] See Darling-Hammond (1994) and Teitel (2001) for descriptions of the professional development school model, which involves collaboration among university education programs and local K-12 educators.

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Why Schools Turned to Job-Embedded Professional Development

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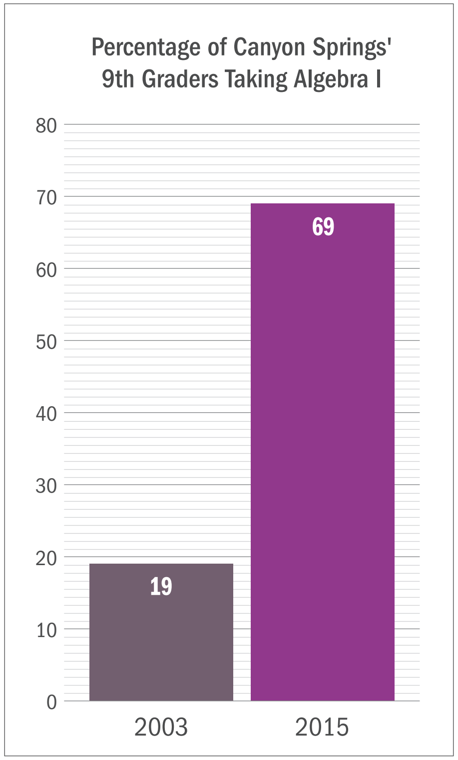
Why Schools Turned to Job-Embedded Professional Development

Both McNair and Canyon Springs high schools created intensive, job-embedded professional development opportunities for their algebra teachers in response to a broader push in their districts to enroll more students in higher-level mathematics courses. Prior to this effort, there were essentially two tracks in high school mathematics: One for students who planned to attend college and a second for those who did not have college-bound plans. At Canyon Springs, the percentage of freshmen who took Algebra I more than tripled between 2003 and 2015—from 19 percent to 69 percent. This increase coincided with the elimination of below grade-level high school mathematics courses offered to students. In 2003, more than 60 percent of incoming freshmen were enrolled in below grade-level courses (e.g., Introduction to Algebra), but those courses have now been eliminated. At McNair, the level of mathematics coursework required for graduation increased since 2000—all students must now successfully complete Algebra II—and the graduation rate has remained stable. During this same time frame, McNair's student population has become increasingly disadvantaged, with roughly 10 percent of the student population eligible for free or reduced-priced lunch in 2000, compared to more than 30 percent in 2015.

Figure 1. Percentage of Canyon Springs' Grade 9 Students Taking Algebra 1: SY 2003–SY 2015



Mastering—rather than simply *taking*—Algebra I is essential for success in subsequent, higher-level mathematics courses. Thus, both Canyon Springs and McNair had to rethink the way Algebra I was taught, since it was now being offered to many students with lower levels of prior mathematics achievement. Both departments determined that they needed more time during the work week to ensure that their courses were working for all students—not just those who had traditionally been successful.

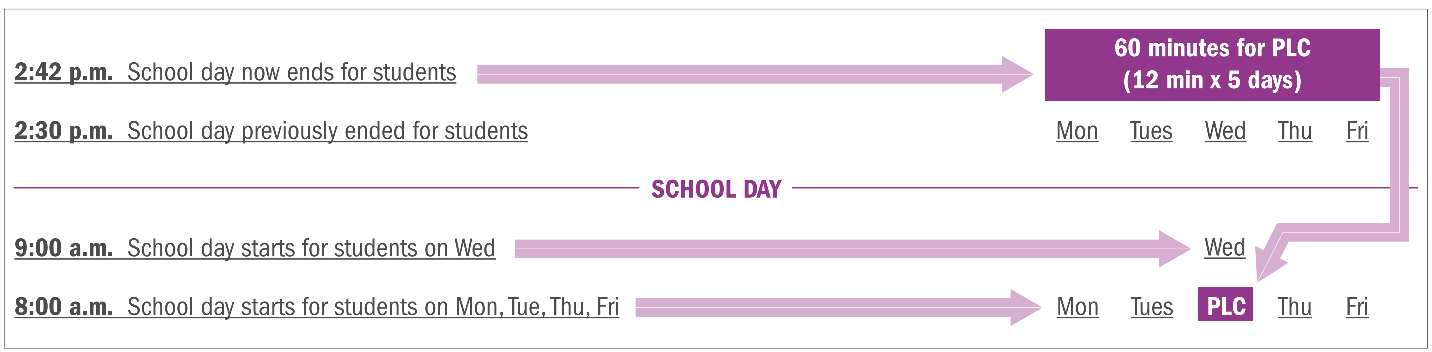
Teachers and instructional leaders at Canyon Springs noted that the current curriculum has been useful for guiding and supporting instruction, but also emphasized that it is the quality of teaching and learning that moves the needle for students. According to one math coach, the actual program mattered less than how it was implemented: “It was the implementation of the program and teachers willingness to move [their classroom practice].”

In Canyon Springs, an outside professional development organization encouraged the school to create collaborative learning time each week as part of a larger project in which the organization worked with district- and school-level instructional leaders to promote collaborative learning among mathematics departments.

At McNair, ongoing collaboration began in the 1990s through the school’s partnership with the local university as a professional development school. McNair’s designation as a professional development school involved close collaboration among preservice faculty in education, student interns, and McNair mathematics teachers. This included university faculty coteaching classes with McNair teachers, McNair faculty serving as mentors for university interns and student teachers, and both faculties collaborating to discuss common issues in mathematics education and undertake joint research projects. As this university-school partnership became solidified, the district began offering early release days for all grade- or subject-specific teachers to collaborate. The McNair mathematics department used the regularly scheduled time—two hours every two weeks—to further integrate its work with the university and then, after the professional development school grant was completed, to sustain the mathematics department’s collaborative learning.

At both McNair and Canyon Springs, the additional time each week for collaborative learning was accomplished by adding a late-start day, in which students begin the school day later (8:30 a.m. for Canyon Springs and 10:00 a.m. for McNair), so that teachers can meet as a group. Both districts have managed to sustain this model by altering the start and stop times of the other four days of the school week, dispersing the time used by collaborative morning meetings across these days. This model is cost-effective because it does not require paying teachers extra for the time they collaborate each week; that time is built into the work day and work week.

Figure 2. Example of Altering the Bell Schedule to Create Weekly Time for Teacher Collaboration



Although expanding access to higher-level mathematics was the primary impetus for both schools' decision to establish job-embedded professional development opportunities for their mathematics teachers, another factor was a commitment to ongoing professional growth. This was particularly true at McNair, where most of the school's mathematics teachers were trained by the local university and served as student teacher interns at McNair. The student teaching experience provided ongoing opportunities for undergraduate students to collaborate with university faculty and practicing teachers regarding the best ways to engage students in learning mathematics deeply. As interns were hired and began teaching in the McNair mathematics department, new and experienced teachers continued to discuss the emerging challenges related to teaching; collaboration of this quality was considered an essential and attractive element of the job. McNair's principal noted that the mathematics department holds its collaborative time as "sacred," even more so than do other departments, because its teachers use the time to delve into substantive issues related to teaching.

"You can do whatever you want to, but just don't take away our department time." McNair's principal, paraphrasing how the mathematics department views competing buildingwide initiatives

6 Professional Learning Communities at Canyon Springs and McNair

Professional Learning Communities at Canyon Springs and McNair High Schools

Although each high school has been implementing professional learning communities for varying lengths of time, there are some overlapping features. Both schools have designated leaders who are responsible for planning their collaborative meetings. An instructional coach organizes the meetings at Canyon Springs, and the department chair assumes this responsibility at McNair. Both groups meet before school—Canyon Springs for one hour each week and McNair for two hours every other week. Time for the collaborative morning meetings is created through a late-start day for students.

Table 3. Professional Learning Communities at a Glance

Canyon Springs High School	McNair High School
Led by school-based instructional coach	Led by department chair, but teachers take turns leading sections of meetings
Weekly, one-hour meetings before school	Biweekly, two-hour meetings before school
Meetings include mix of department-wide and algebra-specific topics and breakout sessions	Meetings include mix of departmentwide and algebra-specific topics and breakout sessions
Strong emphasis on analyzing student assessment data	Mix of emphases over time: Development of curriculum and assessments; analysis of student work; lesson study
Strong initial support from external PD provider and ongoing support from district-based coach	Strong initial and ongoing support from local university responsible for training secondary mathematics teachers in region

Canyon Springs' meetings tend to focus on the analysis of student assessment data from common formative and summative assessments. Formative assessments include chapter and unit tests, while summative assessments are district-wide midyear and end-of-year Algebra I assessments. Meetings at McNair have focused on a number of different topics, and their format has evolved over the years. Like Canyon Springs, reviewing common student assessment data has been an ongoing focus, but teachers have also created and refined their own curriculum and conducted lesson study—described in more detail in the next section—during their collaborative meetings. As part of this evolution, the McNair department chair often delegates responsibility to teachers to lead parts of their collaborative meetings. Teachers take turns doing this based on the direction of group and individual teacher interests.

Canyon Springs' collaborative meetings were introduced several years ago by an outside professional development provider. The provider worked closely with district- and school-level instructional leaders to establish the structure and focus of these meetings and to train local staff to continue the work after the provider was no longer working with the district. McNair's collaborative meetings grew out of a much broader, long-term relationship with the local university. Although the university is not as heavily involved with the school as it was in the 1990s, it continues to provide inspiration for the focus of some of McNair's collaborative meetings, including the previously referenced lesson study program.

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Implementation of Professional Learning Communities

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Implementation of Professional Learning Communities

Canyon Springs' professional learning community (PLC) grew out of a district-wide initiative to launch such communities in every high school, using a late-start day so teachers can meet for an hour each week at their schools. The weekly meetings are organized to provide time for the mathematics department to meet as a whole and time for algebra teachers to meet separately as a group. Depending on the goals of the meeting, time can be allotted exclusively to the algebra subgroup or to the department as a whole. The mathematics department chair sets departmentwide meeting agendas, and algebra teacher leaders set the agendas for the algebra subgroup.

Table 4. Instructional Leadership at Canyon Springs

Leader	Affiliation	Primary Role(s) Related to PLCs
Consultant	External Organization	• Introduce PLC structure to district • Train district and school leaders to continue this work postconsultancy
Mathematics Specialist	District	• Support school-based leaders with PLC implementation • Support teachers with enacting PLC material in classrooms
Principal	School	• Encourage school-based instructional leaders and teachers to invest in weekly PLC meetings
Department Chair	School	• Organize and lead weekly mathematics department PLC meetings • Support algebra PLC teacher with algebra-specific issues
Algebra PLC Leader	School	• Organize and lead weekly algebra subgroup PLC meetings • Work with department chair to solve algebra-specific issues

When the work relating to PLCs started in 2009, the district hired an external consultant to help determine how best to organize the weekly hour of collaboration—both departmentwide and algebra-specific meetings—to maximize teacher engagement and productivity. For the next few years, the consultant worked closely with the district mathematics specialist, the department chairs, and algebra subgroup teacher leaders, as they were responsible for carrying this work forward independently.

One of the first things the consultant worked on was setting the tone for open, honest communication. He argued that unless teachers feel safe, they won't critique each other's ideas and discuss challenging issues related to their own teaching. Without such an environment, the meetings would be superficial and the mathematics department chair, who previously worked in the business community, welcomed such strategies. In her experience, the chair thought that honest, open discussion was sometimes inhibited because educators were overly worried about hurting someone else's feelings.

Figure 3. Sample PLC Meeting Agenda

Time: 7:00 a.m.–8:00 a.m.

1. Departmentwide check-in (10 minutes)
2. Analyze formative assessment data by course (30 minutes)
3. Plan for targeted instruction (10 minutes)
4. Group share out and summary of next steps (10 minutes)

The consultant also introduced student data analysis as a focal point for Canyon Springs' professional meetings, as well as a common structure for the meetings. One advantage of making student data the focus of professional learning is that it is often easier for teachers to analyze difficulties in their students than to identify difficulties in their own teaching. Specifically, the types of data he introduced and that continue to drive weekly meetings include student performance data on common quarterly and end-of-course assessments areas of weakness within and across classes and, based on these analyses, develop action plans to deal with problem areas. Meetings typically include data print-outs for teachers to review and discuss in a department context and then in course-specific subgroups. Teachers reported appreciating the common focus of student data because it provided focus and concrete areas in need of improvement. The district mathematics specialist continued to support the implementation of the collaborative meetings as initially developed by the consultant group after the work was completed.

Participants in Canyon Springs' algebra subgroup meetings include not only Algebra I teachers, but also teachers who lead an algebra support class, called Algebra Lab, designed for students who are behind grade-level and need extra time. The Algebra Lab teachers have an intentionally flexible curriculum that allows them to target specific knowledge and skill deficits, leveraging the data shared in weekly meetings. For example, if students are struggling with fractions in an algebra unit that involves solving equations with fractions, the Algebra Lab teachers can customize the next week of instruction to address specific misconceptions and skill deficits in fractions. Such collaboration and flexibility in the supplemental course allows Canyon Springs to provide differentiated support to struggling algebra students on a weekly basis, rather than waiting until the end of a grading period, when it is too late to turn student performance around.

> "The disparity was from 10 percent to 90 percent!"
>
> Canyon Springs' mathematics specialist, referring to the disparity in assessment expectations between two teachers on the same assignment.

Canyon Springs has extended its student assessment work to include common course grading criteria, which it credits the district mathematics specialist for helping establish. When the specialist began working with Canyon Springs, she described how differently teachers graded the same assessment: "The disparity [in passing rates] was from 10 percent to 90 percent!" across teachers for the same assessment, which was "eye opening" for her and all the algebra teachers. She helped school-based leaders and teachers to create a rubric, which led to lively discussions in their professional learning meetings about levels of mastery and ultimately improved grading consistency across algebra faculty at the school. This collaboration also led the school to develop a creative way to support mastery while simultaneously supporting struggling students—many of whom also were in the school's Algebra Lab support classes. Algebra students can retake any assessment for which they have not demonstrated mastery, which is a score of 70 percent correct. They may continue retaking assessments throughout the grading period, which rewards students who work hard and are willing to revisit material that was initially difficult for them to learn. Canyon Springs now has a course grading system that is more consistent and more strongly assessment-based rather than participation-based. Before Canyon Springs began this work, algebra letter grades were highly subjective, based on the expectations of individual teachers (e.g., a "C" grade from two different algebra teachers did not necessarily reflect the same level of student mastery in each course), an approach that was problematic for placing students in subsequent mathematics courses.

The district specialist also supported Canyon Springs' common assessment and grading work indirectly, through articulation with middle school teachers. She has met with the middle school teachers to discuss the knowledge and skills needed to succeed in Algebra I in order to ensure consistent expectations at Canyon Springs. When she began this work, the specialist learned that the qualifying test being used to place students in Algebra I in middle school had an unacceptably low cut score of 30 percent correct. She said, "When I first started, the cut-off was 30 percent correct. I upped it to 60 percent." Not only did the specialist encourage schools to raise the cut score, she followed up with teachers to help them analyze data from the qualifying examination and develop targeted instructional plans to address areas of weakness more broadly in the middle school mathematics curriculum. The Canyon Springs teachers applauded the specialist's support in improving middle school placement policies, which later benefited their work at the high school level.

Although Canyon Springs' collaborative meetings have been primarily fueled by assessment data and assessment principles (e.g., grading standards), the school has begun to use collaborative time to analyze its instructional practices. The state's adoption of more challenging academic content standards introduced extended, real-world tasks into the district curriculum. These extended tasks require students to do more in terms of thinking and explaining as compared with a more typical teacher-directed lesson in which students learn more passively. Not only were these tasks new for teachers, they were new for students—especially those who struggled in mathematics in the past. Some Canyon Springs teachers noted that many of these students would not even attempt to solve the new extended-task problems initially, but they do so now. Teachers credit this improvement to productive discussions in their collaborative meetings about how to implement these tasks well. They also cite the direct support they have received from the district mathematics specialist when she visits their classrooms.

McNair's PLC involves more components than does the Canyon Springs model, as it has steadily evolved for more than two decades in close collaboration with the local university. Like Canyon Springs, McNair's PLC model incorporates regular time for teachers to collaborate; but meetings are conducted every other week for two hours, rather than every week for one hour. Also similar to Canyon Springs, the school has benefited from external support in creating and sustaining their PLCs, but the support has been from the local university, rather than a consultant. Specifically, the university received a grant about 25 years ago for McNair to be a Professional Development School. This funding was designed to establish a long-term relationship between McNair and the university and to support the ongoing development of both novice and experienced teachers. In this model, university faculty and McNair teachers coteach classes, McNair faculty serve as mentors for university interns and both faculties work together on research projects of common interest. This intensive partnership allowed teachers and university faculty to collaborate formally and informally within and beyond the school day, exchanging and applying ideas related to improving mathematics education. The partnership has produced a steady stream of interns who are later hired to teach at McNair because of the overlap in mathematics education training and philosophy. This overlap is conceptual in nature and assumes that students need more opportunities to actively engage in understanding and applying mathematics (see National Council of Teachers of Mathematics, 1989, 1991, 2000) than what is seen in a more traditional, teacher-directed instructional approach.

After initial funding for the professional development schools ended in the late 1990s, the university and McNair continued to actively collaborate on joint research projects and information sharing opportunities that inform both the university's work with preservice teachers and McNair's work with practicing teachers (e.g., McNair's current biweekly PLC model).

One reason that McNair teachers say this long-term collaboration with the university has worked so well is because of the collegial attitude of the university faculty with whom they have worked. According to McNair faculty, had there been a hierarchical dynamic between university faculty and McNair teachers, any attempt at collaboration would have failed. As one teacher noted, "I can see this [model] not working well in other places if you get somebody that's on their high horse from the university and doesn't really appreciate the teachers as professionals."

> "You want to make sure he or she is curious mathematically and going to push people mathematically."
>
> McNair department chair, on the traits McNair looks for in a new teacher

In many cases, practicing McNair coteachers were former student interns at the local university. Thus, there has been continuity between what preservice teachers learn in their coursework and internships and what practicing teachers apply in their classrooms. A McNair teacher said that interns who transition to teaching in the department have a clear understanding of the culture of the mathematics in the building. When McNair teachers work with interns or hire new teachers from the outside, they view mathematical curiosity as one of the most important traits of potential success in their professional community. McNair is known as a place where mathematics teachers are highly collaborative and reflective of their work.

McNair's unique, synergistic relationship with the local university has produced a stable, vibrant culture of professional learning that is, in many ways, unique and extends well beyond biweekly PLC meetings. However, there are several key aspects of McNair's professional learning culture and structures that apply to schools with limited resources and with less external support. First, the McNair teachers took (and continue to take) seriously the fact that many of their students were not engaged or successful in learning the content. Rather than focusing on factors outside of their classrooms or the school, teachers focused their collaborative learning time squarely on the material students were learning and what they, as teachers, could do to make it more meaningful to their students. They wondered why the content did not resonate with students. They asked whether the content could be presented in a way that was more coherent and more engaging for more students. They used their collaborative meeting time for consideration of these questions and to the development of possible solutions. As McNair's teachers challenged themselves to understand why some students were not engaged in learning algebra, they deepened their own understanding of the content in the context of teaching.

> "I think we all feel pretty strongly that we need to know mathematics far beyond where are students are."
>
> McNair department chair

> "Putting ourselves in the position to be curious and wondering and challenging each other."
>
> McNair algebra teacher on one of the benefits of their ongoing collaboration

The McNair teachers eventually determined that their mathematics curriculum was disjointed and superficial. This conclusion, they determined, partially explained why so many students forgot content immediately after a test. Teachers began to ask one another about the big ideas of algebra. They spent more time trying to distill these ideas clearly and succinctly for students, resulting in a storyline of interconnected ideas that algebra students could follow throughout the course and on to subsequent courses. This was not trivial work; it required teachers to dive deeply into the mathematics—much deeper and more analytically than their students. This was a primary focus of their collaborative learning community for several years. The teachers believed this time was well spent because its outcomes formed the foundation of their future collaborative work, including the development of common sets of curriculum materials and assessments and a greater focus on instructional routines that supported deep student understanding. Like the teachers at Canyon Springs, McNair teachers found that a common focus on curriculum and assessments was essential to their productivity as a learning community.

Figure 4. Examples of Big Ideas in McNair's Algebra Course

- Relationships can be represented with a table, graph, or symbolic rule, and fluency among these allows access to making predictions and answering questions about real-life phenomena, as well as abstracting the mathematics away from particular circumstances.
- Each function family is distinguished by:
  - Unique algebraic/symbolic rules
  - Unique graph shape/features
  - Unique evaluating procedures
  - Unique solving procedures
  - A set of real-world contexts that the table, graph, or symbolic rule models well
  - Function families that show helpful patterns of change in their tables
- Generalized procedures can be used to create formulas or to prove statements.

With regard to the development of curriculum and assessments, McNair mathematics teachers do not use an algebra textbook. Instead, they use tasks and activities that they have developed and refined (and continue to evolve) over the years in their collaborative meetings. They use common end-of-unit and end-of-course assessments that are aligned to the big ideas and tasks they have developed. McNair teachers also use a standard rubric for grading constructed response questions on assessment items. The rubric includes six levels of achievement for both accuracy (e.g., To what extent was the problem answered correctly and, if there were errors, how severe were the errors?) and the quality of the explanation (e.g., To what extent was the explanation complete and clear?).

To calibrate scoring on the final examination, McNair assigns pairs of algebra teachers to the same room to score constructed response items. If there are disagreements after the items have been independently scored, the scoring teachers reach resolution as a pair or reach out to other algebra teachers for input as needed.

Table 5. Grading for Accuracy and Explanation Quality

Level—%	Accuracy	Explanation
0 = 0%	Nothing of value	Nothing of value
2 = 25%	Something relevant, but not much	Something relevant, but not much explanation
4 = 50%	More than one major mistake	Missing several pieces of explanation
6 = 75%	Right idea, but non-trivial error	Missing some explanation (major issue)
7 = 87.5%	Final answer incorrect (noncritical error)	Some ambiguity
8 = 100%	Fully accurate	Fully explained

As McNair's teachers anchored their algebra courses and assessments to big ideas and essential questions, they moved to designing their instruction to engage more students in actively learning this content. Previously, most teachers in the department followed a traditional, teacher-directed model, in which students played a more passive role in learning the material. The teachers questioned the basic principles of this approach, since many students understood the material only superficially. As one teacher said, "We know that if we stand at the board and do a nice clean presentation, we can all pretend like everybody made sense of it." As they further reflected on their instruction, the teachers realized that their practices were designed to minimize student confusion. Although well intentioned, this approach was actually robbing students of opportunities to learn to think for themselves. Students' confusion in mathematics opens pathways for authentic learning. As one teacher stated, "You actually did them [students] a favor by allowing them to have some dissonance, and consider what's going on."

> "Hopefully, we're encouraging students to say 'Ok. I have a new function in front of me. What sort of table patterns or graph shape, or any other properties does it have? What's its inverse going to look like? How is that going to behave?"
>
> McNair department chair, on the conceptual mindset for students that they are trying to develop

Over the course of several years, as a key focus of their PLC meetings and a research emphasis among university faculty, McNair's mathematics teachers began to change their instructional routines in fundamental ways. They moved from being teacher-directed to being student-centered. Rather than asking a series of rhetorical, closed-ended questions, they asked questions that made students explain their thinking and expose their reasoning. Rather than regularly providing students with many exercises to complete over short periods of time, teachers developed larger investigative tasks—some requiring two full days of instruction—during their collaborative lesson to help them further focus their collaborative meetings on this type of in-depth instruction. The opportunity resulted from a grant with the university, which provided resources for substitute teachers so McNair teachers could observe each other's lessons as part of the cycle. Lesson Study originated in Japan and involves a cycle in which teachers collaboratively plan, implement, and refine a common lesson. Although there are variations, teachers in a typical cycle conduct research and prepare lessons as a group, teach those lessons in their own classrooms, and then return to reflect as a group on how the instruction went and how the lessons can be improved. They then teach the lesson again, making further refinements as needed and as a group, before documenting what was learned across the complete cycle. The Japanese model has been adapted and implemented in classrooms in the United States during the past 15 years (Hiebert & Stigler, 2000; Stigler & Hiebert, 1999; Takahashi, Lewis, & Perry, 2013)

Table 6. Subtle Shifts in Questioning

Open-Ended Questions (Too Broad)	Target Prompts/Questions (More Specific)
"What do you think?"	"Well, show me what you've tried so far."
"Are there any questions?"	"Are there problems that you feel like you need to talk about more?"
Lower student engagement	*Higher student engagement*

Lesson Study inherently promotes continuous improvement, a key element of McNair's overall approach to teaching. Beyond this larger project, the department also exhibited a continuous improvement mindset in more subtle ways, such as how teachers reflect on particular aspects of lessons or how they phrase questions to students. One of these more modest adjustments has produced measurable improvements in student engagement for an experienced algebra teacher in the McNair mathematics department, which he then shared with other teachers during their biweekly morning meeting. He noticed that students often tune out to general questions, such as "What do you think?" He hypothesized that this might be true because these types of questions are asked frequently and perhaps because they lack specific references to the work students are doing. The teacher decided to make a slight adjustment, replacing "What do you think?" with "Well, show me what you've tried so far." Similarly, he replaced "Are there any questions?" with "Are there problems that you feel like you need to talk about more?" He reported to the group that the difference in student responsiveness in favor of the new approach was considerable. The department's atmosphere of continuous improvement allows teachers to look for formal and informal opportunities inside and outside the classroom to improve teaching and learning.

8 Challenges and Facilitating Factors

Challenges and Facilitating Factors

Both high schools in this profile were located in districts that had created regular time for teachers to collaborate during the work week. They accomplished this by conducting one late-start day for students, creating time for teachers to meet together that morning. By modestly lengthening the remaining four school days of the week, the districts were able to create time for collaboration at no extra cost and with support from the local teacher unions.

Having the time to meet, however, does not necessarily translate into productive collaboration. At both schools, teachers were committed to using the time for ongoing professional development rather than dealing with other administrative pressures or viewing the time as an additional preparation period. One reason that both mathematics departments used the additional time for ongoing professional development was outside influences. In Canyon Springs, that influence was an outside professional development provider and a strong district coach who ushered in collaborative learning communities, illustrating how to structure meetings to engage adult learners and what types of learning activities to focus on first. At McNair, positive interaction with university professors and a steady influx of interns and student teachers shaped the department's approach to, and appreciation of, collaborative learning in both formal and informal settings. This eventually evolved into a culture of continuous improvement and professional growth, expanding well beyond what teachers accomplished during their biweekly meetings.

Both schools also have strong instructional leaders, a factor that is critical to launching and sustaining professional development initiatives. At Canyon Springs, the school-based mathematics coach was instrumental in the success of the collaborative learning community, and the principal's support also signaled to staff that this work was a priority in the building. He communicated the importance of making the most of time in professional learning communities to support the school in meeting its student achievement goals, often attending meetings unannounced. McNair's department chair was central to the vibrancy of its learning community, but other teachers in the department also actively led aspects of the school's collaborative model and contributed significantly to its culture of improvement. The school's principal has also been an advocate of the department's commitment to collaborative learning within the context of broader, school-wide initiatives.

These professional learning communities are vibrant, in part, because they reflect and adapt to local contextual factors. Canyon Springs' instructional leaders have been careful to implement only work that teachers are ready to handle. Although they are a newer community than McNair and have not spent as much time focusing on instructional issues in their learning community, Canyon Springs teachers are moving toward this stage as a group. Had they tried to do too much too soon, it is likely that Canyon Springs teachers would not have responded as well to their work with common assessments and grading. Given McNair's longstanding relationship with the local university and its reputation in the district as a tight, stable group, the school has been intentional about how new teachers are introduced to and supported in their community. McNair minimizes the number of courses new teachers deliver, and new teachers always have experienced teachers as mentors when they teach courses for the first time. McNair provides opportunities for teachers to gradually take on additional leadership opportunities over time and as they are ready.

As districts and schools consider creating or bolstering job-embedded professional development opportunities for their mathematics teachers, they are likely to encounter challenges. For example, it is not possible in every district to institute late-start days for students so that teachers have time during the school day to collaborate. They may need to look for additional funding to support time outside of teachers' contract week to collaborate. Many schools are not located in close proximity to a university with an innovative preservice teacher preparation program. They would not be able to replicate McNair's internship model and would be forced to think more creatively about how to tighten the connection between preservice and inservice training. Regardless of context, however, the similarity of experience at Canyon Springs and McNair high schools suggests that teachers will respond positively to well-structured opportunities to reflect deeply about the content they teach and how well students understand that content.

9 Key Considerations for Education Decision Makers

Key Considerations for Education Decision Makers

When considering how best to implement a practice within a local context, it is important to consider the insights gained from a variety of sources. Table 7 highlights how key findings from a systematic literature review of professional development (Walters, 2014b; see https://www2.ed.gov/programs/dropout/professionaldevelop0914.pdf) and implications of those findings were reflected in the districts and schools profiled for this brief. A separate perspective brief from this project highlights reactions from practitioners in the field to findings from the systematic literature review (Walters, 2016; see https://www2.ed.gov/programs/dropout/professionaldevelopmentperspectivebrief.pdf).

Table 7. Findings From Professional Development Literature Review

The strongest professional development programs…	Program developers or administrators should consider…	Was this reflected in Canyon Springs and McNair?
…are intensive, sustained, collaborative and tightly linked to practice.	…altering the supporting structures for such intensive, job-embedded professional development.	At both sites, mathematics teachers had regular time during the work week to collaborate. This was accomplished through a late-start day for students, which allowed teachers to collaborate as a department or as a group of algebra teachers before school either on a weekly or biweekly basis. The focus of the meetings varied by site and over time, but virtually all meetings were connected to the content algebra teachers taught and the extent to which students understood that content as determined by formative and summative assessments and samples of student work.
…recognize that teachers may need support in understanding the mathematical concepts they are required to teach	…incorporating an explicit focus on developing teachers' mathematical content knowledge. This focus may be particularly important for teachers at the elementary and middle school levels	At McNair, teachers realized that the knowledge they gained from many of their college mathematics classes did not directly translate to the high school courses they taught. They spent several years collaborating to articulate the big ideas of algebra, deepening their own conceptual understanding in the process and using these ideas to build their own algebra curriculum. At Canyon Springs, teachers have strengthened their content knowledge as part of their assessment work. They devote time in their collaborative meetings to revisit key algebra concepts as they set specific criteria for mastery criteria and assess student understanding of these key ideas.

The strongest professional development programs...	Program developers or administrators should consider...	Was this reflected in Canyon Springs and McNair?
...focus on strengthening students' reasoning and conceptual understanding, including important prerequisite Algebra I topics.	... Identifying programs with strong supports for stimulating and supporting students' reasoning and understanding, including topics that are important for students to master before they enter a formal Algebra I course.	There was a strong professional development focus at both sites on developing students' conceptual understanding and strengthening their reasoning. At both sites, collaborative meetings focused on analyzing student assessments and assignments, to assess understanding and reasoning. At Canyon Springs and McNair, collaborative meetings addressed, in part, the prior knowledge and skills students lacked, which became the focus of support classes for students who needed additional instructional time.
...can be critical to the successful implementation of broader programs or initiatives designed to improve student success in algebra.	...supporting larger initiatives with a strong professional development component and collecting implementation data as the initiative is rolled out.	At Canyon Springs, the professional learning community was central to a broader initiative to eliminate all remedial courses for ninth-grade students. The initiative included a strong emphasis on monitoring student data, which was the primary focus of the collaborative learning community. McNair's professional learning model supported a department-wide initiative to increase the coherence of the mathematics program and increase the proportion of students who succeeded in higher-level courses.
...include explicit connections to the classroom, including the use of video or other technologies that support reflections on teacher practice.	...investing in professional development programs that use classroom video as part of structured, concrete learning opportunities for algebra teachers.	At both sites, professional development communities were tightly linked to the classroom, including student work and assessments, and instructional strategies. McNair implemented a lesson study program for a period of years, which involved collaboratively planning, teaching and debriefing a common lesson. Although both schools had explicit connections to practice, neither site utilized video to support this work.
...provide structured opportunities for algebra teachers to collaborate with one another and with other experts through multiple mediums (e.g., online).	...including online and face-to-face delivery mechanisms	Although neither site collaborated online, both professional learning communities were heavily influenced by external experts and used online technologies to share resources. At Canyon Springs, the external provider helped launch the school's collaborative meetings, offering a structure to guide meetings and support for district- and school-based instructional leaders to sustain the work after the provider's work was done. At McNair, ongoing collaboration with the local university not only helped establish its community, but sustained it over a period of many years. Both departments used email and shared drives to exchange instructional resources to support their collaborative meetings.

10 Appendix

Appendix. Sampling, Data Collection, and Analytic Methods

In selecting sites for Promoting Student Success in Algebra I, the primary 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, in order to maximize the utility of practice profiles for 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.

Relative to professional development, our specific expectations were as follows:

Professional Development: Selected sites were districts or schools with professional development programs targeted at improving the teaching and learning of Algebra I or courses that promote algebraic thinking (e.g., programs that develop algebraic thinking in Grades 6–8). Professional development activities included workshops or seminars developed and delivered by district staff and professional learning communities formed within or across schools in the districts. The focus of professional development activities included specific content (e.g., understanding the big ideas of algebra, linear relationships), pedagogical techniques (e.g., questioning strategies, use of multiple representations of algebraic concepts), instructional materials (e.g., how to implement adopted materials or other lessons and tasks focused on algebraic concepts), and assessments (e.g., how to implement formative assessment lessons). The district or school should have a systematic approach to implementing and supporting these types of professional development activities.

Both sites profiled here also provided evidence of improvement. The sites significantly increased the proportion of students enrolling in and successfully completing Algebra I and subsequent mathematics courses during the past decade. At Canyon Springs High School, more than 500 students were enrolled in remedial algebra in ninth grade 10 years ago. Today, all ninth-grade students take Algebra I or higher. The school has seen steady increases in the number of students who have completed Algebra I and beyond successfully over this timeframe. At McNair, the student population has grown from 10 percent eligible for free or reduced-priced lunch in 2000 to more than one-third in 2015. A greater proportion of students now successfully complete Algebra I and Algebra II by graduation. McNair's overall graduation rate has also remained high (88 percent) as the school has increased the accessibility and rigor of its high school mathematics program.

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 24 educators were interviewed across the two sites: 4 administrators and 8 teachers in Canyon Springs, and 2 administrators and 10 teachers in McNair. 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 Dedoose, 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.

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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.

2284_09/17