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Instructional Coaching Strategies to Support Student Success in Algebra I

Research Brief

This research brief is one of five that summarize the literature in different topic areas[1] related to helping struggling students in Grades 6–9 succeed in algebra. The research briefs are part of the *Promoting Student Success in Algebra I* (PSSA) project funded by the U.S. Department of Education's High School Graduation Initiative (HSGI). The PSSA project at American Institutes for Research is designed to provide actionable information for educational program developers/administrators in three ways. First, these research briefs together will summarize research on five strategies being implemented by HSGI grantees that help struggling students succeed in Algebra I, a critical gateway course for high school graduation and enrollment in college. Second, the project includes a forum for practitioners—district program developers/administrators and teachers—to make connections between the findings from the research briefs and their daily work, with the results of these discussions 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.

This brief describes what is known about instructional coaching as a strategy to improve the quality of algebra teaching and learning. District- and school-based mathematics coaches are increasingly being used

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[1] The five topic areas are Curricular Alignment, Instructional Practices, Supplementary Learning Supports, Professional Development, and Instructional Coaching.

across the country—more than one third of all U.S. public schools have at least one mathematics coach or specialist, and national organizations point to job-embedded coaching as a key ingredient for high-quality professional development (West & Saphier, 2009; Croft, Coggshall, Dolan, & Powers, 2010; National Staff Development Council, 2010). Although the roles, responsibilities, and goals of mathematics coaches vary depending on the resources and needs of particular districts and schools, coaching is fundamentally about helping teachers become better at what they do, and an emerging body of research on the topic is highly relevant to program developers/administrators.

Helping algebra teachers improve their teaching practices is as important and challenging as ever with the implementation of more rigorous College and Career Readiness Standards in mathematics and the wide-scale adoption of the Common Core State Standards for Mathematics (CCSSM; National Governors Association Center for Best Practices [NGACBP] & Council of Chief State School Officers [CCSSO], 2010), which incorporates mathematics standards from high-performing countries (Kober & Rentner, 2011). Just as students are being held to higher standards of learning, teachers are being held to higher standards of teaching, heightening the need for algebra instructional coaching programs that are informed by the latest research.

What types of instructional coaching programs support student success in Algebra I? To answer this question, we conducted a literature review. The process we used is described in the Appendix. Some of the research in this brief meets the highest level of rigor described by the What Works Clearinghouse.[2] We included other less rigorous studies because they represent the best available evidence on coaching programs targeted to supporting student success in Algebra I. We reviewed studies of coaching models for which the coach served as a collaborative, technical expert with expertise in mathematics teaching, rather than less commonly researched models for which the coach served as the formal evaluator or as a peer without technical expertise (Taylor, 2007). Studies reviewed for this brief also have (a) a *prominent coaching component;* that is, coaching activities (e.g., lesson planning, observing, coteaching, debriefing) had to make up one third or more of the professional development intervention being evaluated and (b) a *focus on direct lesson feedback;* that is, the coaching program had to have a direct feedback component, either in real classroom time or through the analysis of video with individual or groups of teachers.

Before we summarize key findings from the literature, it is important to recognize that the research on algebra coaching is still quite new, so very few rigorous evaluations of algebra-specific coaching programs have been conducted. However, there is still plenty of exciting new research about instructional coaching that program developers/administrators should consider. For example, programs that involve well-trained, expert coaches and highly structured forms of feedback appear quite promising. The same is true for coaching programs that incorporate classroom videos into the feedback provided to teachers and for programs with explicit strategies to promote students' algebraic reasoning.

[2] The What Works Clearinghouse was created in 2002 by the Institute of Education Sciences to be a source of information regarding what works in education. See http://ies.ed.gov/ncee/wwc/DocumentSum.aspx?sid=19 for the standards used to evaluate studies.

Synthesis of the Literature

We summarize this emerging body of research into three groups: studies of coaching programs that specifically target the teaching of algebra concepts or the development of algebraic thinking; studies of programs that focus on other mathematics topics; and studies of new, Web- and video-based delivery mechanisms that are being used to scale up the influence of high-quality coaches and coaching programs.

Coaching Focused on Algebra and Algebraic Thinking

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We were not able to locate any rigorous evaluations of coaching programs targeted specifically to algebra teachers in Grades 6–9. However, we did find some descriptive studies that focused on algebra coaching in these grades and rigorous studies of coaching programs that focused on algebraic thinking in earlier grades. A longitudinal descriptive case study of the Silicon Valley's Mathematics Assessment Collaborative (MAC) indicated that instructional coaching may have contributed to students' mathematics achievement in Grades 6–9, including Grade 8 scores on a statewide Algebra I assessment. Teachers who participated in the MAC were coached individually or collaboratively approximately 20 times a year. The coaching focused primarily on how to implement high-leverage performance tasks, which frame one- to two-day lessons that teachers use every few weeks to assess students' conceptual understanding and ability to problem solve. Seventy percent of the students who were assigned to teachers who participated in the MAC passed the statewide Algebra I exam, compared with 52 percent of the students who were assigned to teachers who did not participate in the collaborative. Further, a subset of MAC teachers received a more intensive form of the coaching program, and their students had even higher passing rates on the statewide assessments and performance assessments than those of teachers who received the general MAC coaching program—up to 24 percent higher in some cases (Paek, 2008; Paek & Foster, 2012).

Another study focused on the Chicago Algebra Initiative, which was designed to increase the proportion of Grade 8 students taking Algebra I and succeeding on the district's end-of-course Algebra I exam. The initiative included algebra curricular supports, professional development workshops, and university courses for teachers, along with a strong coaching component. Each coach worked with the algebra teacher or teachers in several schools, providing primarily in-class support (e.g., modeling, observing, coteaching) to help with the implementation of the algebra curriculum. The coaches also spent time meeting with teachers outside of class (e.g., planning, debriefing lessons, holding small-group meetings). Participating teachers reported favorable impressions of their joint work with coaches and noted that their coaches directly influenced their knowledge and practice. One key finding from the evaluation of the initiative was that teachers who attended 75 percent or more of the professional development workshops performed the highest of any subgroup in the sample; their students had a passing rate of 58 percent on the end-of-course Algebra I exam, which was more than double the passing rate of students with teachers who attended fewer than 75 percent of the professional development workshops (Deiger et al., 2009).

Students of teachers who participated in the CGI coaching program outperformed students of nonparticipating teachers on measures of algebraic understanding.

Although not targeted to algebra students in Grades 6–9, the extensive body of research—including rigorous, experimental trials with strong evidence from the What Works Clearinghouse (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007)—stemming from the Cognitively Guided Instruction (CGI) program suggests that coaching may enhance elementary students' achievement in algebraic reasoning. A key tenet of the CGI professional development program is making student thinking (e.g., approaches, conceptions, misconceptions) the focal point of teaching. Jacobs, Franke, Carpenter, Levi, and Battery (2007) conducted a rigorous experimental study of a CGI program designed specifically to improve K–5 students' ability to reason algebraically. The program sought to help students see algebra as generalized arithmetic and to understand the relationship between numbers and the fundamental properties of operations. Although the CGI program evaluated in other studies was primarily workshop based (e.g., Carpenter, Fennema, Peterson, Chiang, & Loef, 1989), this study included workshops and a strong coaching component. School-based coaches participated in the workshops and met with volunteer teachers between workshops, and the CGI workshop providers also spent time with teachers in classrooms. After one year, the program produced positive impacts on teacher and student outcomes. Teachers who participated in the CGI program generated more problem-solving strategies than nonparticipating teachers, and their students outperformed students in the nonparticipating teachers' classrooms both on a written test measuring students' understanding of the equal sign and in interviews that measured students' understanding of relational thinking. The study also provided data highlighting the importance of allowing teachers time at the beginning of the professional development program to reflect on their dispositions and beliefs related to learning mathematics as adults and teaching mathematics to students (Battery & Franke, 2008).

Coaching Focused on Other Mathematics Topics

There were significant differences in favor of students in schools with coaches in years 2 and 3, and the achievement gains were larger for students in the higher grades.

There have been other studies of mathematics professional development interventions with strong coaching components, but the coaching did not focus specifically or exclusively on algebra. Campbell and Malkus (2011), using a rigorous randomized design, found a positive impact on achievement in Grades 3–5 for students in elementary schools with mathematics coaches who also received extensive training prior to and during the three-year study. Each coach was an instructional leader from one of the study's five districts and agreed to take five mathematics content courses in the two years preceding the study and one leadership course during Year 1 of the study. The coaches were responsible for all the mathematics teachers in their schools, and they spent time inside and outside of classrooms working with individuals and groups of teachers on lesson planning, delivery, and reflection. The coaching did not produce a significant impact on student achievement after one year, but there were significant differences in favor of students in schools with coaches in Years 2 and 3, and the achievement gains were larger for students in the higher grades.

During this same time frame, and also using a rigorous experimental design, Garet and colleagues (2011) evaluated the impact of a two-year professional development program with a strong coaching component. This program provided content and pedagogical support on the topic of rational numbers to Grade 7 teachers—unlike other studies reviewed so far, the schools rather than the teachers volunteered for the study—and the coaches were external providers who also delivered the workshop component of the study's professional development program. The approximately 20 hours of coaching per teacher per year included individual and small-group meetings, such as lesson planning, modeling, coaching, and debriefing. The topic of rational numbers was selected as the focus of the professional development because this topic is considered an important prerequisite to success in algebra (National Mathematics Advisory Panel, 2008; Kilpatrick, Swafford, & Findell, 2001; National Council of Teachers of Mathematics, 2000, 2006). The study's coaching program failed to produce positive effects on teacher knowledge or student achievement after one and two years of the program. Teachers who received the study's professional development program were more likely to implement questioning strategies emphasized in the professional development after one year than teachers in the control schools, but these strategies did not translate to improved student achievement, the ultimate goal of the study (Garet et al., 2010; Garet et al., 2011).

Other studies of mathematics coaching have examined the role of the coach with individual teachers and within a larger system of professional support—particularly when teachers are trying to carry out ambitious forms of instruction. Several studies reported that the most productive coaching activities involved narrowing the focus of the coaching to specific practices and activities in which the coach and the teacher coparticipated, such as coteaching, observation, and joint planning and reflection (Jackson & Cobb, 2013; Neufeld & Roper, 2003; Olson & Barrett, 2004; Bradley, 2007). Another study that used social network analyses indicated that teachers sought the advice of the coach on the basis of several criteria, including the coach's level of experience and familiarity with the curriculum and the teacher's history of working with the coach and perception of the coach's ability. The researchers noted that the teachers' perceptions of the coach's ability did not involve assessing the coach's instructional expertise with the Instructional Quality Assessment (IQA), a rubric developed by mathematics education researchers at the University of Pittsburgh and used by the district to measure mathematics instruction (Gibbons, Garrison, & Cobb, n.d.). The finding suggests that teachers' perceptions of a coach's ability may be linked to the most pressing challenges they are facing (i.e., implementing the district curriculum) and focus on characteristics that are relatively easy to measure (i.e., experience and familiarity with the curriculum are easier to measure than specific instructional practices).

Web- and Video-Based Coaching Delivery Systems

Beyond these studies of traditional, face-to-face coaching interventions (i.e., coaches worked with teachers to plan, model, and reflect on lessons in the same physical space and in real time), several recent studies point to the promise of coaching programs that use Web-based technologies and video in real or delayed time as a medium through which teachers receive explicit feedback about specific aspects of their teaching. One of the coaching programs with the strongest evidence base focused on improving the quality of teacher-student interactions and student engagement using domains from the Classroom Assessment Scoring System-Secondary (CLASS-S). Allen, Pianta, Gregory, Mikami, and Lun (2011) conducted a rigorous experimental trial of the My Teaching Partner-Secondary (MTP-S) program, a Web-based, remote coaching program based on the CLASS-S. Teachers in this program send video recordings of their lessons to trained instructional consultant-coaches who then use the CLASS-S to highlight a brief lesson that illustrates positive student interactions or areas for growth. The teachers are asked to review the clips, respond to prompts from the coach, and then participate in a 20- to 30-minute follow-up phone conference with the coach. Each three-part cycle repeats twice a month, or roughly 20 times a year. Teachers in the treatment group received one year of

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the My Teaching Partner program, and student achievement data were collected at the end of the intervention year and the following year. Although there were no significant differences in student achievement at the end of the intervention year, there were significant differences in the post-intervention year in favor of students whose teachers participated in My Teaching Partner. The positive impact applied to all subject areas (including mathematics) and was equivalent to an improvement from the 50th to the 59th percentile in student achievement. Given the rigor of this research design, this finding is very important within the emerging research base on instructional coaching.

Edmondson (2006) carried out a small, experimental evaluation of another remote, Web-based coaching program, the Telepresence-Enabled Apprenticeship Model of Professional Development (TEAM-PD). The TEAM-PD platform includes three components: video conferencing technology used for meetings between the teachers and their remote coach; a "virtual observer," a portable camera that automatically tracks the teacher throughout the lesson and records the lesson on a DVD; and a "virtual teacher," a system that projects the coach's image on a large video screen at the front of the classroom for real-time modeling of instructional practices. Volunteer teachers in both the treatment and control groups attended an in-person workshop where they learned how to implement a game designed to improve Grade 5 and Grade 6 students' understanding of decimals. The person who developed the game also delivered the in-person workshop. Teachers in the treatment group participated in coaching activities using the TEAM-PD system, in which the developer of the game and deliverer of the professional development served as the remote coach; teachers in the control group continued to receive in-person, workshop-based professional development activities. The remote coaching activities included lesson planning, coteaching/modeling, and debriefing. The focus of the coaching was initially on the mechanics of teaching the game, but over time, the focus shifted to emphasizing the underlying mathematics content. The results of the study are not generalizable given the study's small sample size, but students in the treatment group did outperform students in the control group on a short assessment of the main topics emphasized in the decimal game (64 percent vs. 25 percent correct for the treatment and control groups, respectively).

Teachers in the treatment group scored significantly higher than control teachers on the IQA, and their students scored significantly higher on the two end-of-unit tests.

Another experimental study of coaching linked the use of video with the review of student assessment data. Supovitz (2012) evaluated an intervention designed to link elementary mathematics teachers' use of data with specific, high-leverage instructional strategies. Volunteer teachers in the study's treatment group received data on their students' end-of-unit tests plus feedback on a videotaped lesson they taught during the unit. Teachers in both the treatment and control groups participated in small-group meetings at the end of the unit to discuss their students' data, but the treatment group discussed data in conjunction with specific feedback about their teaching, which was based on a structured rubric, the IQA. The researchers found that teachers in the treatment group scored significantly higher than control teachers on the IQA, and their students scored significantly higher on the two end-of-unit tests.

Although they did not use an experimental design and were less rigorous than the preceding studies, other evaluations of professional development programs with video-based feedback components further suggest that this type of professional development may be promising. Seidel and colleagues (2005) evaluated two forms of a computer-based professional development program; one form used participating teachers' own videos as part of the professional development program and the other form used other teachers' videos. The teachers who incorporated their own videos reported higher levels of engagement and thought that the professional development had greater potential for fostering ongoing change in their teaching, compared with teachers who watched other teachers' videos. Borko, Jacobs, Eiteljorg, and Pittman (2008) evaluated a professional development model that incorporated video to help teachers improve their students' ability to reason mathematically. The heart of the professional development program was a four-step Problem-Solving Cycle (PSC) whereby teachers met as a small group to solve a problem and plan a lesson based on the problem; implement the lesson, which was also videotaped; reflect in a small group on the teacher's role in the lesson; and reflect in a small group on student thinking in the lesson. The study implemented three PSCs over a two-year period, and the researchers concluded that the teachers became increasingly engaged and the small-group discussions became increasingly productive after each cycle.

Implications for Program Developers and Administrators

The research on coaching is in its early stages, and the results are mixed. More research is needed to untangle the results from early studies and advance the field. However, the current research base does suggest that certain aspects of coaching are important for program developers/administrators to consider as they develop and implement programs to improve the teaching and learning of algebra. Coaching still has the potential to help break down the "egg crate" isolation of teaching, first described by Lortie (1975) nearly 40 years ago and still experienced by many teachers today. The concluding table summarizes the key research findings, including the limitations, with implications to consider.

Table 1. Key Findings and Implications for Program Developers and Administrators

The strongest coaching programs...	Program developers and administrators should consider...
• Use well-trained, expert coaches.	• Ensuring that well-trained coaches are hired or that coaches with less training are properly trained. This may have an impact on the timeline of the coaching program because the coaches need to be trained before they begin working with teachers.
• Include structured feedback on a narrow set of instructional practices.	• Identifying the key aspects of instruction that the coaching will target. Instead of launching general coaching initiatives, select a rubric that is research based and focus on a subset of practices that teachers can digest and incrementally improve.
• Emphasize strategies to improve student engagement and student reasoning.	• Promoting coaching programs with strong student engagement and reasoning components. Increasing student engagement and promoting student thinking might involve coaching programs with classroom discourse strategies, interesting tasks, problem-solving activities, or all of the above.
• Take more than one year to produce an impact.	• Crafting policies that give the coaching programs enough time to take root. It may take two to three years to get the anticipated results, and this information should inform funding decisions and evaluation timelines.
• May have a stronger influence on volunteer teachers.	• Specifying the teacher population the policy is targeting. Confirm that there are a sufficient number of volunteer teachers to warrant the coaching initiative. If the coaching program is required of all teachers, the program may affect the nonvolunteers differently than volunteers. Additional time may need to be incorporated into the planning and implementation process for nonvolunteers to fully engage with the program.
• May use Web- and video-based delivery systems.	• Investing in video technology to allow coaches and teachers to communicate, depending on the structure of the program (number of teachers, number of coaches, geographic area, etc.). A growing body of research suggests that investing in video technology can allow coaches and teachers to efficiently share information, particularly when videos are used as the basis of in-person or remote feedback meetings focused on a narrow, specific set of instructional practices. This approach may be especially useful to districts that have a limited number of coaches or have teachers spread out across a wide geographic area.

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Appendix

To conduct the literature review, we followed the same process used in other briefs in this series by including descriptive, theoretical, and explanatory research on instructional coaching that spans a wide range of methodological approaches (e.g., high-quality experiments, quasi-experimental studies, descriptive studies, case studies), sources (e.g., educational journals, research organizations, national content-specific organizations), and disciplines. In addition to conducting a rigorous search of existing literature, we contacted experts in the field who are conducting research on these educational programs to identify research findings not yet published and included them in this review. We used a four-part, hierarchical selection process as the basis for including the studies summarized in this brief: subject (algebra vs. mathematics vs. other subjects), grade level (Grades 6–9 vs. Grades 1–5), year of publication (since 2005 vs. before 2005), and level of evidence (strong vs. moderate vs. low, based on standards informed by the What Works Clearinghouse; see http://ies.ed.gov/ncee/wwc/). We prioritized studies that focused on algebra or mathematics in Grades 6–9, that were published since 2005 and that had strong or moderate evidence. A fully exhaustive review of the literature is beyond the scope of this brief. Instead, we focus on research studies that are most relevant for instructional coaching as strategies for promoting student success in Algebra I.

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