Intensified Algebra:
A Comprehensive Program for Struggling Students in Double-period Algebra Classes

Project Summary

The *Intensified Algebra* project emanates from two years of discussions among UMLN members. Consistent with most school districts nationally, Algebra 1 has the highest failure rate of any high school course in UMLN districts. The mathematics directors and superintendents in UMLN districts independently identified the high failure rate in 9th-grade algebra classes as their top mathematics priority and have encouraged development of a program to address this need.

A June 2007 inventory of practices in UMLN districts revealed remarkable convergence on a strategy of increasing the amount of algebra instructional time for under-prepared students, i.e., making Algebra 1 a double-period course. All UMLN districts offer some version of this course. Most are conceived solely to provide extra instructional time, sometimes with slight curricular modifications (e.g., tethering together disparate instructional materials for algebra instruction and remediation). Despite the extra time in algebra classes, no UMLN district reports district-wide improvements in 9th-grade algebra performance.

Using a design-based research approach, the project is developing and studying a new program, called *Intensified Algebra* that is engineered for use with students who are enrolled in the double-period algebra classes that are commonly scheduled for underprepared students. Central to the design plan is the assumption that students who struggle in mathematics need more than just a good algebra curriculum to be successful. Thus, in addition to a rigorous mathematics core, our approach addresses the social, affective, linguistic, and strategic cognitive and metacognitive dimensions of learning mathematics. The project's extensive research component will inform the program's development and revision, and will lay the foundation for future research studies.

The project's goals are as follows:

Goal 1: Iteratively design and test student and teacher materials for a full-year, 9th grade, double-period algebra program that integrates effective approaches for teaching algebra with instructional features that, independently, have proven to be effective with struggling learners.

Goal 2: Develop and test materials and strategies that enable teachers to effectively implement the comprehensive *Intensified Algebra* program and that help promote collaboration within and across schools among teachers of the course. A particular target will be novice or inexperienced teachers, who disproportionately teach the double-period classes.

Goal 3: Develop and test structures and tools that promote the program's scalability in large, urban districts and elsewhere. The project will investigate the feasibility and effectiveness of leveraging technology to organize and deliver at scale consistent, high-quality supports for program implementation.

Intensified Algebra transforms thinking about how to teach algebra to underprepared students. It presents a unique, coherent program that incorporates into algebra instruction areas that historically reside outside of the domain of typical algebra classes but are fundamentally important to students' success. The program aims to influence students' beliefs about themselves as effective mathematics learners and their attitudes about mathematics, as well as their teachers' beliefs about the mathematical capabilities of underprepared students. The tight linkage of the design-based research and the program development components offers a viable, productive model for collaboration between researchers and developers.

This program will have broad applicability nationally in helping school districts address the needs of underprepared 9th grade algebra students. The project builds upon two years of discussion, planning, and proof-of-concept development. The project's close connection with UMLN teachers and district leaders increases the likelihood that *Intensified Algebra* will address the needs of the students, teachers, and administrators and can be implemented at scale. The materials and tools developed in this project provide a platform for teacher-development activities that will support program implementation once it is completed.

Key Design Features of *Intensified Algebra*

The key design features of *Intensified Algebra*, derived from two years of planning and proof-of-concept development by the project's design team, are described below.

1. Algebra core: The core algebra instruction is organized around adaptation of algebra instructional materials built upon a technology-based delivery system developed by Agile Mind. Agile Mind, Inc. is an education technology company that was formed in 2001 to produce, market, disseminate, and support educational innovations developed at the Dana Center. In developing the course's scope and sequence, topics that are most critical for success in algebra and future mathematics courses were identified; a rigorous treatment of that content was then planned, targeting students' conceptual understanding, associated skills, and related problem solving and reasoning capabilities. Agile Mind uses technology-based representations—visualizations, animations, and simulations—to allow students to explore algebra situations, increase their attention to mathematically important aspects of those situations, explicitly show relationships, and connect ideas. Such representations offer potential to help students learn difficult mathematics concepts. Developing *Intensified Algebra* includes an intricate process of analyzing existing Agile Mind algebra lessons and then adapting them to enhance their use with struggling students, i.e., overlaying specific routines and structures that are part of the design for the new, double-period program.

2. Efficient review/repair strategies. Connecting new learning with prior knowledge involves both engaging students in tasks and activities that help them access relevant prior knowledge when they need it and "repairing" misconceptions they might have related to that knowledge. *Intensified Algebra* takes a "just in time" approach to review/repair; based upon research with struggling learners, review tasks are strategically placed to help students access prerequisite knowledge and preview upcoming content in the algebra core. Our "repair" strategy is based on research that indicates that learning increases when common mistakes and misconceptions are systematically exposed, challenged, and discussed. In this approach, instructional tasks are designed so that learners confront inconsistencies between their existing beliefs and observed events, then resolve the

conflict through targeted practice and reflective discussion. We draw upon the research literature on algebra teaching and learning to identify common misconceptions and prerequisite knowledge to be addressed.

3. Ongoing, distributed practice. Struggling students need extra practice opportunities. *Intensified Algebra* includes several means to promote ongoing practice of skills, concepts, and principles in tasks and problems. Our approach for such practice is based upon long-standing research that supports the use of distributed or "spaced" practice in mathematics. Practice and review in *Intensified Algebra* are incorporated within the program's curriculum spiral, in homework assignments, and in daily "Staying Sharps"—short problems assigned each day that review previously learned material and reinforce prerequisite skills.

4. Social-psychological interventions: Student motivation, views of intelligence, and engagement are addressed in the *Intensified Algebra* course. As an example, students' beliefs about their intelligence—as a fixed trait (fixed mindset) or one that can grow over time (malleable mindset)—influence their motivation to engage in academic tasks, and consequently, their success, especially in challenging subjects. Malleable-mindset interventions, which explicitly teach students about the brain, its functions, and that intellectual development is the result of effort and learning, have increased students' achievement in middle school mathematics. Building on these findings, the Dana Center and Agile Mind developed the Academic Youth Development (AYD) program, a three-week summer transition program for entering ninth graders that supports students' aspirations for high achievement by teaching them theories of malleable intelligence as well as strategies for goal setting and effective effort; how to learn; and effective communication. Collectively, these form the basis of the youth development component for *Intensified Algebra*. The project is adapting the existing AYD summer materials for use throughout the school year; AYD activities have been strategically incorporated into *Intensified Algebra's* scope and sequence.

5. Supports for enactment of high cognitive demand tasks. Teachers facilitate students' conceptual development when they engage students in problems and contexts with important mathematics and high cognitive demand tasks and draw explicit attention to connections among ideas facts, and procedures. A critical element is the extent to which students are actually cognitively engaged with the task at hand and the mathematics they are learning. A key challenge for all teachers, especially those with less experience, is to learn how to enact tasks so that the level of cognitive demand is retained, then orchestrate discussions using students' responses to advance the mathematical learning of the whole class. *Intensified Algebra* assists teachers with this process by embedding questions and prompts within the student materials that help students get started on activities and focus on important mathematical ideas and relationships. Instructional tasks primarily are designed for partner work (rather than individual or small group work) to promote reflection, discussion and explanations. In addition, the Advice for Instruction (teacher guides) provides detailed information for teachers to support task enactments, e.g., likely student responses, key discussion questions.

6. Tools that help students organize information and support metacognitive awareness. Metacognitive and cognitive strategies that support students becoming self-directed learners promote students' problem solving capabilities and mathematics achievement. However, struggling learners have difficulty organizing and interpreting information and

complex processes. Thus, a key feature of *Intensified Algebra* is a set of well-defined routines and tools that assists students in making connections within algebra, organizing information, and making their mathematical thinking "visible" to them and to their teachers.

7. Enhanced formative assessments strategies. The positive effects of formative assessment on mathematics learning are well established. A key aspect of formative assessment involves effectively utilizing evidence gathered about students' learning to adjust instruction to meet students' learning needs. Other key aspects involve teachers' abilities to ask effective questions and engineer high-quality classroom discussions; use mathematics tasks that elicit evidence of learning; and provide feedback that moves learners forward. Typically, individual teachers are responsible for formative assessment. In contrast, *Intensified Algebra* "offloads" some responsibility for formative assessment onto student and teacher materials. Lessons provide multiple means for students to communicate their thinking, and student and teacher materials contain questions and prompts to help teachers probe students' understanding and link responses to suggested next steps in instruction. In short, *Intensified Algebra* contains a comprehensive set of formative assessment activities and tools that provide struggling learners and their teachers with regular and targeted feedback to help them monitor progress, address sources of confusion, and build on the strengths in students' mathematical knowledge to move them toward more advanced thinking and toward regulation of their own learning.

8. Explicit supports for literacy and language development**.** Researchers have begun to understand how literacy and language issues impact learning in mathematics and science classes, particularly with struggling learners, and how to support content learning through the use of simple strategies and tools for language and literacy development. The program promotes better algebra understanding through the use of tools and routines—such as language notes and double- or triple-entry journals, and explicit reading comprehension strategies—to help students build essential academic vocabulary, comprehend and analyze key elements of mathematics problems, explicitly connect different representations of mathematical situations, and reflect upon and communicate their understandings.

Intensified Algebra: **Course and Lesson Structure, Content, and Design**

Course Structure and Content

Course content is organized into ten instructional units, each consisting of roughly three weeks of instruction. Units are subdivided into three "topics"—each of which includes a sequence of lessons about specific mathematics content. Typically, the first and third topics in a unit provide 5-6 days each of instruction on specific themes of mathematics, while the middle topic addresses youth development ideas and builds students' algebraic thinking capabilities via engagement in solving non-routine problems.

Lesson Structure and Content

Each daily lesson is written for 80-minute blocks, which is the typical length of double-period classes in UMLN districts and elsewhere.

A typical lesson has the following components:

- *Daily Preview:* Outline of day's activities that explicitly describes what students will be doing and the purpose of each activity. The preview helps students organize their thinking for the lesson and see the connections among lesson components.

- *Opener*: A 5-10 minute daily warm-up "routine" for transitioning into class work. The goal is to help focus students on the upcoming lesson and access relevant prior knowledge, and to provide teachers with formative assessment data. The warm-ups typically involve mathematics problems involving concepts or skills needed for the lesson but may also involve questions for private reflection and/or partner discussion.

- *Core Learning Activities:* 20-30 minutes of instruction adapted from Agile Mind lessons to promote learning of essential algebra content. Activities typically feature high-cognitive-demand tasks situated in real-life contexts along with online animations of mathematically important aspects of the tasks. Tasks are augmented by regular use of routines that provide new ways for students to organize and access the content, e.g., graphic organizers to help students make connections among concepts; triple-entry journals to actively access and reflect upon prior knowledge and/or process new mathematics vocabulary; a "think-pair-share" routine for partner work; and explicit reading instructional strategies to aid comprehension of problems and help students monitor understanding as they read the algebra lessons. Routines to support frequent formative assessments (e.g., individual whiteboard work) to help teachers and students monitor learning are also included.

- *Process Homework:* 5-10 minute partner routine to review the previous lesson's homework. It promotes communication among students about mathematics and their mathematical thinking, and also teaches students to take ownership of their own learning. Students process their mid-unit and end-of unit assessments with their partners using an expanded version of this routine.

- *Consolidation Activities:* 20-30 minutes of instruction designed to review/repair prior knowledge required for upcoming lessons (i.e., preview the algebra content and correct misconceptions), provide additional opportunities for practice and to deepen conceptual understanding, and/or address youth development topics. These are typically designed as partner activities.

- *Staying Sharps:* A daily set of six short problems that provides distributed practice with algebra and prealgebra skills and use of metacognitive tools. Staying Sharps are also used to preview upcoming content; i.e., they help students review relevant prerequisite knowledge and also provide formative assessment data to teachers about their students' knowledge of perquisite concepts and skills. Teachers typically assign Staying Sharps either as homework or to be done during the consolidation period.

- *Homework:* Roughly 30 minutes of additional work outside of class time to help develop students' confidence and abilities to work independently in mathematics and to provide additional practice.