

## Cultivating Mathematical Habits of Mind in All Students

### Background

EDC's *Transition to Algebra: A Habits-of-Mind Approach* (TTA) project is developing, piloting, and field testing an intervention course to be taken concurrently with Algebra 1 in support of success in algebra for at-risk students. TTA focuses on a small number of underlying ideas and builds essential algebraic habits of mind that, in alignment with the *Common Core Mathematical Practice Standards*, include abstracting regularity from repeated reasoning, using general purpose tools strategically to organize mathematical thinking, seeking and using structure, communicating with precision, and puzzling and persevering through mathematical problems. The approach is designed for a diverse population of students at risk of losing access to STEM coursework and careers. TTA assumes that most students were mathematically capable when they were young and are still clever and that their major impediment in school mathematics is that they believe they're no good at *school*. Therefore, TTA sees its major goal as getting these students back to being as smart and intrepid as they were when they were young. As a consequent strategy, it makes heavy use of logic puzzles with mathematical content. It also builds strong mental mathematics skills and offers student dialogues, discussion prompts, and non-routine "explorations" of rich mathematical tasks to help students learn to think and communicate mathematically.

Our *iPuzzle: Transforming Mathematics Learning Through Social Puzzling* project is developing and researching elements of an interactive puzzle-based environment for use in formal and informal settings. Apps are being designed for both tablet and browser use, and puzzle content is selected from our TTA project. One type of puzzle helps students build the logic of balancing equations, the foundation for algebraic "moves" involved in solving equations and systems of equations. The design aims to explore the affordances of interactive information technology and the possibilities for socially interactive and informal learning. Social solving—students engaging socially over puzzles—reduces pressure on each partner and, through the development of the social "stock" of a puzzle, also raises the incentive to keep going.

### Why Puzzles?

Central to a number of our projects is the use of mathematical puzzles and logic. One beauty of puzzles as an educational tool is that their difficulty can vary independently along two dimensions—prerequisite mathematical knowledge or skill, and the cognitive demand of the puzzle or mathematical "infrastructure" required for solving it. A second advantage is their ability to bridge the gap between formal and informal settings: puzzles are applicable in class but approachable *and appealing* outside of class as well. Also, puzzles are *fun* because they engage the intellect, give permission not to know the solution method before starting, and allow for social collaboration in solving them.

Our project *Implementing the Mathematical Practice Standards: Enhancing Teachers' Ability to Support the Common Core State Standards* is developing Illustrations of the Mathematical Practices, along with a professional development curriculum for teachers of grades 5–10, to support teachers in better understanding and identifying the Mathematical Practices in order to help their students develop these practices. Each Illustration contains a mathematical problem, a

student dialogue that exhibits one or more of the Mathematical Practice Standards, an analysis of the mathematical content and practices, and related resources for teachers and students.

### **Documented Results**

The TTA project team is investigating students' achievement in algebra and changes in their attitudes toward mathematics, as well as teachers' and students' experiences using the TTA materials. We have collected and are currently analyzing both qualitative and quantitative data, classroom observations and student and teacher survey and interview data, and mathematics assessment data.

The TTA project also conducted a District Algebra Supports Study to understand and document the range of district practices and supports offered for students identified as struggling, and the challenges district leaders face in serving these students. Preliminary findings indicate that most districts require algebra for graduation and provide supports in the form of an intervention class covering Algebra 1 content with materials developed by the teachers or within the district.

### **Potential Applications**

The TTA materials were designed for at-risk ninth-grade algebra students and are also being successfully used in other contexts including middle school courses, summer school programs, and at the university level with struggling math students and preservice teachers. The primary use of the Implementing the Mathematical Practice *Standards* Illustrations is for teacher learning, yet several components (including the dialogues, student discussion questions, and related mathematical tasks) can be used with students in grades 5–10. The iPuzzle apps are designed for players of all ages in both formal and informal settings and are being tested with middle school students.

### **For More Information**

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iPuzzle: [ipuzzle.edc.org](http://ipuzzle.edc.org)