Above and Beyond withDigi-Block Mathematics
A Base-10 Program for Learners with Significant Cognitive Disabilities
Akin, Anderson and Rimbey, 2008

RESEARCH-BASED DATA

Above and Beyond is an innovative mathematics program based on sound educational research. At this time, research-based data is available in two forms: curriculum-based research of *Above & Beyond with Digi-Block Mathematics* and a literature review of the best practices on which *Above and Beyond* is based.

Curriculum-Based Research: *Above & Beyond*

The Digi-Block system used by *Above & Beyond* as an instructional medium is applied throughout the program. This system centers on students' continued work with a set of proportional nesting blocks that provide a uniquely accurate model of the base-10 number system. In addition, using concrete, pictorial, and symbolic representations to introduce, clarify, and extend mathematics concepts in a systematic, coherent way is common to both programs. Many of the lessons in the two programs are identical, as is the content development and explicit teaching approach. Three preliminary studies of *Above & Beyond*, a program written specifically for learners with developmental delays, suggest the efficacy of this instructional design for struggling learners.

First Study

History: The first study was begun in December, 2003, when two Arizona high school life skills teachers decided to try using the Digi-Block system to teach number concepts and skills to their students. The teachers had experienced continual frustration because of their inability to help their students "learn math" and function with money. They were hoping that somehow the blocks would offer a way to reach their students.

During the 2003 school year, the teachers experimented with Digi-Block, referring to the Digi-Block website for instructional guidance and allowing the sense-making capability of the blocks to lead their students through the learning process. They were astounded! For the very first time, their students were making sense of numbers and were learning concepts and skills that they had been unable to learn previously, even with instruction!

As a result of the students' progress in these two classrooms, *Above & Beyond with Digi-Block Mathematics* was written, addressing the learning needs of these students with cognitive disabilities.

Results: The table below shows the pre-program results for the 17 students (10 students with moderate mental retardation (MOMR), 7 students with mild mental retardation (MIMR) who were enrolled in these two classrooms throughout the entire period from December 2003 until May 2006.

	# of students instructed	# of students showing improvement	# of students showing no change	# of students showing loss of skill	Statistical significance
COUNTING	17	16	1	0	$p = .001$
MODELING	17	13	4	0	$p = .01$
ADDITION	13	13	0	0	$p = .01$
SUBTRACTION	13	13	0	0	$p = .01$
MULTIPLICATION	9	9	0	0	$p = .01$
DIVISION	6	6	0	0	$p = .05$
MONEY	8	8	0	0	$p = .01$

Second Study

History: The second study involved field-testing the first portion (Unit 1) of *Above & Beyond* among 103 high school students enrolled in life skills curriculum programs. Unit 1 pertains to concepts and skills related to counting, modeling, addition, and subtraction *within the set of numbers 0 to 10*.

Results: The table below shows the learning progress of 103 students with disabilities (7 with severe MR, 73 with MOMR, 17 with MIMR, and 6 with no classification).

	# pretesting *at or above* Unit 1 skill level	# pretesting *below* Unit 1 skill level	# instructed	# showing improvement from instruction	# showing no change after instruction	Statistical significance
COUNTING TO 10	64	39	39	20	19	$p < .001$
MODELING TO 10	25	78	78	56	22	$p < .0000001$
ADDING (sums ≤10)	54	49	12	11	1	$p < .01$
SUBTRACTING (minuends ≤ 10)	35	68	20	19	1	$p < .001$

As expected, students varied greatly in their ability to learn. With that fact in mind, we can draw some tentative conclusions from the data presented in the table.

1. 51% of students instructed in counting to 10 were successful. 49% were unsuccessful. It is at this early stage of instruction that students who may be unable to benefit from the program are identified. Some of these students may learn these skills after a longer period of instruction, but progress, if there is any, will be slow.
2. It is assumed that many students had no prior instruction in modeling (representing numbers with physical materials), so this skill was probably new to them. Of those students who were instructed in modeling to 10, 72% were successful and 28% were unsuccessful. The 28% includes students who were unable to count to 10.
3. The success rate for students who were instructed in addition and subtraction is high, 92% and 95% respectively. *Students who are able to master the basic skills of counting and modeling to 10 are likely to benefit from instruction in more complex skills.*

Third Study

Ongoing: Now that *Above & Beyond* is finished, it is being used in other classrooms in Arizona, Maryland, Pennsylvania, Massachusetts, Maine, Kentucky, New Hampshire, Wyoming, and Hawaii. The third study, current, ongoing, and long-term, is designed with randomized controlled trials (RCT). It involves eight classrooms (grades 1-8) with about 100 students with developmental disabilities and autism. Initial data will probably be available by summer 2008.

Literature Review: *Above and Beyond*

Above and Beyond uses research-based instructional principles that have been shown to result in increased student achievement. These principles include the following:

Research-Based Principles	Evidence in *Above & Beyond*
Active Engagement	Engages students in activities which focus on concept-based tasks which will increase their mastery of those concepts
Computation (Jones, Wilson, & Bhojwani, 1997)	Walks students through the basic skill-building concept for each operation using manipulatives, pictorial representations, and symbolic representations; includes all four operations through addition and subtraction of 3-digit numbers, multiplication by 2-digit numbers to 1000, and division by one-digit divisors through 999
Constructivism (Hudson, Miller, & Butler, 2006; Cawley, 2002; Cawley & Miller, 1989)	Allows students to construct understanding of each concept through the use of base-10 manipulatives and apply that understanding to modified, mathematically sound algorithms for each of the four operations
Direct Instruction (Witzel, Mercer, & Miller, 2003; Carnine, 1997; Tarver, 1996)	Lessons are explicit, sequential, and broken down into small increments **NOTE: See "Teacher-Led Instruction" below.**
Distributed Practice and Motivation (Garnett, 1998)	Ongoing practice is provided as a basis for all instruction, learning, and maintenance of skills; Connections are made to prior learning to facilitate long-term retention and fuller understanding; Activities are on-level with the skills being learned, and an element of "fun" is integrated through games and activities the students enjoy; These three elements, practice, connections, and fun, provide a high level of motivation for the students to learn as a result of success and enjoyment
Effects of constant time delay, peer tutoring, time trials, direct instruction on computation and problem solving skills of students with mild-moderate MR (Butler, Miller, Lee, & Pierce, 2001)	Direct instruction is used for the introduction of each concept/skill, providing continual student practice using a variety of modes (manipulatives, pictures, symbols)
Frequent Assessment (Fuchs, 1995; Peckham & Roe, 1977)	Unit assessments allow teachers to determine mastery of each objective; Anecdotal records allow teachers to track ongoing progress through each lesson
Incremental Instruction (Gersten & Chard, 1999)	Each concept/skill is broken down into specific learning objectives which are introduced sequentially
Memory (Kroesbergen & Van Luit, 2003; Gagnon & Maccini, 2001; Goldman, et. al., 1997; Miller & Mercer, 1997; Mercer & Lane, 1996)	Each concept/skill is broken down into a logical sequence which allows the student to work as long or as briefly as needed – some lessons may take just a few minutes while others may go on for a few days – allows students to commit their learning to memory; ongoing practice and the use of various modes for instruction (manipulatives, pictures, symbols) allows students to make mental connections which will increase memory; each concept/skill is well-connected to prior learning to maximize long-term retention
Multiple Representations (Marzano, 2001)	Uses a variety of representations for each concept including graphic representations, physical models, mental pictures, drawn pictures, and kinesthetic activity, which promote the acquisition of and elaboration on knowledge
Number Sense (Fennel & Landis, 1994)	The sole focus of Above & Beyond is to build a strong sense of number through the place value system so that students can apply their mathematical understanding to real life/job situations and to working with money
Practice and Repetition (Sood & Jitendra, 2007; Mayfield & Chase, 2002)	As each concept/skill is introduced and developed, the students approach the thinking from a variety of vantage points (manipulatives, pictures, symbols) and have opportunities to practice those skills in a variety of contexts: games, skills practice, cooperative learning activities
Problem Solving & Strategy Use (Butler & Lauscher, 2005; Miller & Mercer, 1997; Montague, 1991)	Since the instruction has a constructivist approach (but very strongly guided through prompts), students must problem solve in each lesson as they figure out how to use manipulatives, pictures, and symbols to represent their mathematical thinking

Sequence (Whitehurst, 2003; Darch, Carnine, & Gersten, 1984)	Lessons are sequenced in a logical, systematic way, so that students may build their understanding of each concept
Setting Objectives & Providing Feedback Marzaon, 2001; Wiggins, 1993; Hattie, 1992; Kulik, Kulik, & Morgan, 1991)	Each lesson sets specific, measurable objectives; The teacher is prompted to state the objectives to the student(s) and to provide student feedback based on those objectives which is corrective, timely, specific, and personal
Teacher-led instruction, explicit performance expectations, prompting, structured practice, achievement monitoring, corrective feedback (Woodward, 2004; Woodward & Montague, 2002; Jones, Wilson, & Bhojwani, 1997)	All lessons are teacher-led as students perform explicit tasks tied to specified learning outcomes; teacher prompts are included to allow for structured practice of each math objective; learning outcomes for each lesson are provided so that teachers may provide corrective feedback at each step