Research Base for AIM Higher!® Mathematics Series

The *AIM Higher!*® mathematics program is grounded on solid research into pedagogical methods, instructional strategies, and learning modes. Each principle behind the instruction corresponds to a research-based standard for teaching, and each component of the program is designed to implement these principles in the most effective way possible. The chart below shows some of the elements of the *AIM Higher!*® math program and references to the corresponding research.

Based on NCTM[1] principles for teaching school mathematics: The guiding principles for the *AIM Higher!*® series come from the extensive research conducted by this professional organization. Its books and journals provide comprehensive analysis of the best research in math education. Some of these principles are listed below, with references to relevant research.	National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: National Council of Teachers of Mathematics.
Scaffolding; step-by-step instruction: "Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge" (NCTM). Learning takes place when students are able to move from what they know to what they don't know. The instruction in the *AIM Higher!*® books leads students systematically through a procedure, with small, incremental steps that are easy to follow. This scaffolding approach presents a task at an appropriate level of difficulty, breaks the task into a manageable sequence of operations, and works toward an outcome characterized by internalization of new knowledge. Algorithms for solving problems are presented in such a way as to allow students not only to follow the steps but also to transfer the principles to other, similar problems, thus expanding their knowledge. Throughout the series, concepts are built upon previous understanding and lead to new understanding.	NCTM. (2003). *A research companion to principles and standards for school mathematics.* Reston, VA: NCTM. Hiebert, James. (1999). "Relationships between research and the NCTM standards." Journal for research in mathematics education, Vol. 30, No. 1, 3-19. Van Der Stuyf, Rachel R. (2002). "Scaffolding as a teaching strategy." Adolescent Learning and Development.
Emphasis on mathematical reasoning and higher-order thinking: It is not enough to know facts and be able to perform computations. Students must also learn how to think mathematically and reason logically. In addition to a specific unit devoted to mathematical reasoning, there is an emphasis throughout the book on developing this skill in its many facets. Procedures are not just demonstrated but explained, and students are challenged to grasp the concepts as well as being able to carry out the calculations.	NCTM. (2003). *A research companion to principles and standards for school mathematics.* Reston, VA: NCTM.

[1]The National Council of Teachers of Mathematics (NCTM) is the largest mathematics education organization in the world. Its membership includes nearly 100,000 math educators. It publishes four professional journals, and its *Principles and Standards for School Mathematics* provides authoritative guidelines for excellence in mathematics instruction.

Extensive problem-solving opportunities: "Problem solving is the foundation of all mathematical activity" (Reys, Lindquist, Lambdin, Smith, & Suydam, 2001). "In order to function in our complex and changing society, people need to be able to solve a wide variety of problems. The elementary math curriculum must prepare children to become effective problem solvers" (Burns, 2000). A critical aspect of mathematical competence is the ability to solve problems and to transfer those solution methods to problems in different contexts. Students often lack the strategies to tackle word problems effectively and apply the skills to different problems. Following the work of George Polya, the *AIM Higher!*® books have lessons that focus on identifying the correct operation and on applying problem-solving strategies. This heuristic model is reinforced by extensive opportunities throughout the books to practice problem-solving skills, especially in real-world contexts.	Reys, R.E., Lindquist, M.M., Lambdin, D.V., Smith, N.L., & Suydam, M.N. (2001). *Helping children learn mathematics* (6th ed.) New York: John Wiley. Burns, M. (2000). *About teaching mathematics: A K–8 resource* (2nd ed.). Sausalito, CA: Math Solutions Publications.
Thorough review and practice for students, particularly in explaining their reasoning process: Every lesson in the *AIM Higher!*® books is followed by two pages of exercises. Doing these exercises solidifies what students have learned in the lesson. Multiple-choice questions provide a quick check of understanding. Every set of exercises also contains at least one written-response question that requires students to think through a problem and come up with their own answer. Mastery of a concept is shown when students are able to verbalize the reasoning they are using and the steps they are following. In addition to the exercises following each lesson, there are two pages of extended-response questions at the end of each unit, plus a Cumulative Review section, with one extended-response problem for each unit, at the end of the instructional material.	Schoenfeld, Ph.D., Professor of Education, University of California, Berkeley, draft for 2004 Politics of Education *Yearbook,* edited by Bonnie C. Johnson & William L. Boyd.
Appropriateness for levels of cognitive development: The authors of the *AIM Higher!*® books have tailored their approach to the general levels of cognitive development at different stages. The instruction for middle school, for example, calls on higher levels of reasoning than the instruction for elementary school. As much as possible within the framework of meeting the grade-level standards, expectations are consistent with what is now understood about development of thinking.	cf. research of Jean Piaget

Awareness of multiple intelligences:
There is a stunning variety in the kinds of intelligence that people possess and in the different ways they learn. Not everyone can be expected to learn in the same way, so the *AIM Higher!*® books have a feature called "Another Way" that gives students alternate algorithms for carrying out procedures or a different way of approaching problems. Besides mathematical-logical intelligence, there are also opportunities to use and develop interpersonal intelligence (in group activities) and to explore other intelligences (such as the connection between mathematics and music).

Gardner, Howard. (1983). *Frames of mind: The theory of multiple intelligences.* New York: Basic Books-Perseus Books Group.

Assessment of initial skill level and targeted remediation:
The Pretest in each book enables teachers to identify specific areas of difficulty. Teachers can then choose specific lessons to address those problem areas. This allows individualized programs and targeted remediation for specific weaknesses.

NCTM. (2000) *Principles and standards.* Reston, VA: NCTM.

Diagnosis and correction of error patterns:
A diagnostic test of basic math facts in each book allows teachers to pinpoint specific weaknesses in this area. Just as important is having facility with basic computational skills. In learning the basics, students often pick up error patterns. Sometimes these incorrect patterns give correct answers, and the wrong procedure is reinforced. Each *AIM Higher!*® book contains a diagnostic test that will help teachers identify specific error patterns in students' computations. In addition, the Pretest can be given as a diagnostic test to assess students' initial skill levels.

Ashlock, Robert B. *Error patterns in computation: Using error patterns to improve instruction.* (8th ed.). (2001). Prentice Hall.

Interconnections to other branches of math, to other curricular areas, and to everyday life:
Learning a particular subject without a wider context "often leaves students with a disconnected view of knowledge and fails to reflect the way that real people attack real problems in the real world" (Daniels & Bizar, 1998). "Interconnections among the disciplines … will support learning by making the mathematics curriculum more meaningful" (Sutton & Krueger, 2002). A key to learning is enabling students to make connections between disciplines and between math and their everyday lives. Besides being filled with real-world problems, the *AIM Higher!*® books have a "Math in Use" feature that shows how math concepts appear all around us—in art, nature, geography, sports, music, science, and so on—and how they can be applied in everyday situations.

Daniels, H. & Bizar, M. (1998). *Methods that matter: Six structures for best practice classrooms.* York, ME: Stenhouse Publishers.
Sutton, J. & Krueger, A. (Eds.). (2002). *EDThoughts: What we know about mathematics teaching and learning.* Aurora, CO: Mid-continent Research for Education and Learning.
Moon, J., and Schulman, L. (1995) *Finding the connections: linking assessment, instruction, and curriculum in elementary mathematics.* Portsmouth, NH: Heinemann.

Stimulating presentation that engages students in learning: Not only research but also common sense supports the idea that people learn best when they care about the subject and find it fun and interesting. The *AIM Higher!*® books present the material that students need to know in a way that engages them in learning. Interesting problems challenge students to wrestle with the concepts. In addition, the special feature boxes present interesting or unusual bits of information (like the miscalculations that led to the Great Molasses Flood of 1919, when the city of Boston was inundated by a wave of molasses from a burst tank).	cf. Sutton & Krueger McLeod, Douglas B. (1992). "Research on affect in mathematics education: A reconceptualization." Article in *Handbook of Research on Mathematics Teaching and Learning.* New York: Macmillan.
Interaction between text and graphics: In the *AIM Higher!*® books, text and graphics complement each other to enhance learning. Whenever possible, graphics are used to reinforce visually the concepts being described verbally (Burnette, 1982). In addition, delightful pieces of illustrative art will amuse and entertain students and help them remember what they are learning. This student-friendly design makes the books especially suitable for students who struggle with math.	Burnette, J. (1987) "Adapting instructional materials for mainstreamed students." ERIC Digest [ED 297 557]. cf. Sutton & Krueger cf. McLeod, Douglas B.
Preparation for high-stakes tests: When taking high-stakes tests, students may know the math needed to answer a question but become confused by the presentation of the material. Each *AIM Higher!*® book familiarizes students with what to expect on the state test. Not only is the instruction in the books aligned with state standards; the Pretests and Posttests are modeled after the actual state exams, as are many of the exercises. As a result, the question format is no longer a hurdle to students, and they can concentrate on the mathematics of test questions. They are comfortable taking high-stakes tests because they have successfully solved problems in the same format.	Mehrens, W.A. (December 1989). "Preparing students to take standardized achievement tests." ERIC Clearinghouse: ERIC Digest [ED314427]. Ligon, G.D. & Jones, P. (April 2, 1982). "Preparing students for standardized testing." American Educational Research Association, New York.
Alignment with standards: Finally, all of the lessons in the *AIM Higher!*® books, as well as all the questions on the Pretests and Posttests, are correlated to the state standards for mathematics. In addition, the units in each level correspond to the NCTM Standards for School Mathematics. Having these goals gives a clear focus for the instruction. Learners are more likely to attain the goals if those goals are clearly identified and the way to achieve them is mapped out. The NCTM standards have been thoroughly researched and evaluated and have proven effective over the long run.	Hiebert, James."Relationships between research and the NCTM standards." NCTM. (2003) *A research companion to principles and standards for school mathematics.*