# A Gentle and Cost-Effective Approach to Dramatically Improving Mathematics Education



## Contents



## 1 Introduction

Concerns about the state of mathematics education in the United States are not new and have spawned numerous debates over the last few decades. A wide variety of reforms have been introduced, yet the results have not been particularly encouraging. One reason for this is that the perceived fundamental problems are either not clearly formulated or are not relevant. American standardized test results are one performance indicator, but they represent only a small fraction of what is ultimately significant in a good math education. Even international tests, whose results are often the source of concern do not adequately address the underlying issues.[1] One such important issue that has been identified is

[1]The leading such test is the Trends in International Mathematics and Science Study (TIMSS) which shows the US scoring consistently below participating Asian countries (and that is not including India, China, and Vietnam, which did not participate but which are top performers in math and science).

the inability of a great number of American school children to correctly perform basic mathematical computation starting with arithmetic. Although this needs to be addressed as early as possible in a student's education, this still leaves one question unanswered: is there anything else worth learning in mathematics? Answering this question requires looking closely at what constitutes mathematical thinking, something that unfortunately currently happens only starting at the university and graduate school level. Input from higher education is mostly lacking at the primary and secondary school levels, and mathematics educators rarely come from the ranks of mathematics professionals. Fortunately, models of successful cooperation between educators and mathematics professionals do exist and it is the goal of Gentle Knowledge to bring together American and foreign-educated mathematicians, teachers, and other education professionals, taking the best proven approaches from each group, to address the worrying trend in mathematics education.

In other countries, in Russia in particular, a rich tradition of interweaving higher mathematics with school mathematics education has evolved. In fact, mathematicians have considered it an honor and a duty to engage students of all levels and grades in a mathematical dialogue that is both informative and inspirational. The Gelfand Correspondence Program in Mathematics started by the famous mathematician I. Gelfand is an example of such a model, where students experience the essence of mathematics, nonstandard problem solving, while interacting with professionals. Luckily, doing mathematics does not require engaging in original research, nor does it require replacing school teachers with mathematicians. The lessons learned by members of the Gentle Knowledge team show that a carefully defined notion of problem solving – almost completely different from the de facto definition – lies at the heart of mathematics education. Furthermore, this modified definition not only helps achieve the currently recommended education objectives but opens up new possibilities for both students and schools. Student ability to solve nonstandard problems eliminates fear of mathematics and applies directly to other subjects like computer science whose potential has not yet been explored. Schools can finally move from viewing technology as a buzzword to viewing technology as a useful learning medium, and students can move away from being technology consumers to being technology creators.

The methodology outlined in this document is flexible enough to benefit those for whom mathematics is a challenge as well as elite students. In-service teacher training is at the heart of this approach, and it empowers teachers while increasing their content knowledge. The ideas introduced by Gentle Knowledge are simple and well-tested and perhaps more importantly, they can be easily modified to accommodate the specific needs of a school or school district without undermining the existing educational goals. Ultimately, the effectiveness of this system is not based on new abstract ideas in mathematics education but on the concrete experience and knowledge of the Gentle Knowledge team that has successfully applied the principles outlined below, both in the United States and abroad.

## 2 Core Principles and Objectives

1. CHANGING THE MATHEMATICS CULTURE IN SCHOOLS: Curiosity needs to replace the current fear of mathematics among both students and teachers. Students and teachers need to embrace the intellectual challenge of solving a problem instead of feeling insecure about their abilities. The creative process of problem solving, not test scores, should motivate students. Nothing can replace the feeling of accomplishment that comes with an elegant problem solution or a working computer algorithm. Test-based assessment has an important role to play as long as it does not lower standards and expectations. High standardized test scores are best achieved through quality education that sets high goals not test preparation that meets low standards.

2. PROBLEM SOLVING IS KEY: The goal of a successful mathematics education is the ability to solve problems, not the ability to memorize and repeat disjointed facts. Emphasis needs to be placed on a relatively small set of thought-provoking problems rather than on a large number of repetitive exercises that can be quickly and easily solved by memorizing a few patterns. The latter approach may meet short-term standardized test-driven goals, but it fails to leave students with any useful long-term skills. Of course, acquiring computational fluency, which is not to be confused with the inadequate problem solving through pattern memorization, is a fundamental building block of a mathematics education.

3. MATHEMATICS HAS AN INTERNAL AND EXTERNAL PURPOSE: Topics like calculus which are incredibly useful in all branches of science, engineering, and economics should not be beyond the reach of any students. Although advanced students may choose to cover some topics in depth, all students should be exposed to the mathematics underpinning the functioning of modern society. The best way to do this is to develop the material with specific climactic results in mind. Thus, students who begin to explore the notion of functions in middle school can study some of their more useful and interesting properties when they reach calculus in high school. Mathematics is cohesive and all topics should be presented with a specific purpose and related to previously discussed ideas.

4. TEACHERS ARE THE HEART OF THE SOLUTION: Teaching is difficult and teachers need all the support that they can get.[2] Unfortunately, mathematics teachers often lack the type of mathematics background that would make their jobs easier. Fortunately, teachers can acquire significant content knowledge while teaching if provided with carefully designed teaching material and stress-free expert instruction. Teacher motivation stems from student accomplishments, which in turn makes teaching an even more prestigious profession. Perhaps most importantly, there should not be any tension between mathematics education and professional mathematics.

[2]According to a 2007 Public Agenda survey, "Lessons Learned: New Teachers Talk About Their Jobs, Challenges and Long-Range Plans", teachers are more interested in on-the-job training and support than higher pay.

# 3 Main Problems being Addressed and Proposed Solutions

The problems and solutions outlined below come out of the combined experience of the Gentle Knowledge team members who have been both teachers and professional mathematicians. Because of the unfortunate gap between professional mathematics and mathematics education, teachers and school administrators are not expected to be aware of all of these issues and they are not a reflection of any incompetence on the part of educators. For too long, academic debates about the underlying problems in school mathematics have been theoretical in nature, calling for revolutionary changes without proposing realistic and practical measures. The systemic problems below are serious, yet they can begin to be rectified immediately without waiting for potentially unrealistic reforms that take years, if not decades. Implementation details are covered in section 4.

**Problem:** There is not enough content knowledge among teachers, and this severely affects the quality of mathematics education. Teachers are sometimes uncomfortable with questions that they cannot answer, and students, sensing that something is wrong, develop a fear of mathematics.

**Solution:** For a long time pedagogy has received much more attention than the substance of mathematics. The dichotomy between methodology and mathematics is artificial at best and counterproductive at worst. By remedying this situation we can immediately improve other problematic areas. By exposing teachers to the "way of math" and providing them with the necessary historical and theoretical background we will enable them to better explain to their students why mathematical concepts, constructions, conventions, algorithms, and notation are the way they are. We do this by addressing the topics that are immediately relevant in the classroom and not by submitting teachers to grueling reeducation involving topics that are better suited for graduate or advanced undergraduate work. Two issues are of universal importance:

- PRECISION: by presenting teachers with a relatively small set of simple but precise fundamental definitions underlying the curriculum, we can instantly raise the level of understanding of both teachers and their students. Similarly, by providing teachers with teaching material consisting of a heavy dose of logical reasoning problems (a rarity under the current system), we can begin to cultivate the most important skill – the ability to solve problems and precisely communicate their solutions. Precision is not just a tool of mathematics but is also a tool vital to clear and understandable teaching.[3]

[3]The problem with a lack of precision is clearly illustrated by the following problem taken from an actual 8th grade test: "find the smallest consecutive integers whose sum is greater than 16." One glaring problem with this formulation is that it is not clear how to compare sets of integers (which is smaller and which is bigger). Problems like this abound and baffle students. The student (tutored by a Gentle Knowledge team member) who lost points because of an "incorrect" solution to this problem felt less confident about her abilities. Meanwhile, a younger sibling was confused by the enormous number of different concepts: fractions, ratios, decimals, and percentages that he had to learn. A simple and precise definition

- COHERENCE: by helping teachers connect seemingly disparate topics through teaching material that demonstrates the unity of mathematics we achieve two goals. First, we force students to return to topics that have been covered previously, thereby strengthening their understanding, and secondly, we motivate further topics.[4]

Although the importance of both precision and coherence is intuitively clear, it takes years of classroom experience and mathematical expertise to create the kind of material that is easily digestible by students and teachers. Gentle Knowledge provide both the material and the prerequisite instruction.

**Problem:** Problem solving is not a centerpiece of the school curriculum. Moreover, what is currently perceived as problem solving is actually a series of simple exercises that require pattern memorization not creative thinking. New material is presented as a set of prototypical exercises that are repeated, with minor variation, ad nauseam in homework assignments, quizzes, and tests. The most apparent problem with this approach is that students, when faced with non-standard problems (the ones most common in the real world outside standardized tests), give up quickly, as soon as they realize that none of the patterns they have committed to memory are immediately applicable. The current attitude in school mathematics of "either you get or you don't" (an attitude easily impressed upon students) stems from an incorrect understanding of the problem solving nature of mathematics.

**Solution:** Experience shows that the best solution to this problem is to attack it head-on. Students need problems that force them to think and teachers cannot be burdened with creating such problems from scratch. Gentle Knowledge provides teachers with problems that have been successfully used to train mathematicians, scientists, and engineers and provides the training to get the most out of problem solving sessions. The goal of such problems is not to train only the most advanced students to become world-class mathematicians or olympiad winners but to reinforce the growing knowledge base of all students while gently habituating them to a more prolonged and nontrivial thought process. The implications of this approach are manifold. Beyond the obvious acquisition of new problem solving methods, students, even those who arrive at partial solutions to challenging problems, build self-esteem that is based more on concrete accomplishments than teacher praise or good grades. Furthermore, students learn to effectively communicate solutions verbally and on paper, which is simply not possible with straightforward exercises involving simple numerical answers. At the same time, because teachers do not need to worry about creating such thought-provoking problems or independently solving

of each of those terms would clearly demonstrate that they are all fractions and that would alleviate a great deal of the confusion.

[4] A good example of this is the connection between linear equations and similar triangles – a connection that almost never appears in classrooms but which unifies algebra and geometry.

the ones they are given (although this is encouraged), they can enjoy the benefits of significant student achievement while improving their own content knowledge.

**Problem:** Many students perceive mathematics, unlike most other subjects, as particularly difficult, scary, and often, not worth the effort. This makes teaching more difficult than it already is. Overcoming the frustrations of both teachers and students has been a priority of various reforms and the result has been something that is often called "hands-on activities" and "real world applications." Unfortunately, the experience of the Gentle Knowledge team members shows that although students sometimes prefer such projects as a less stressful substitute for tests and quizzes they perceive it as busy work which limits its usefulness.[5]

**Solution:** The best way to attack boredom and fear is to give teachers the tools that help their students achieve a tangible sense of accomplishment. One way to do this, introducing true problem solving, is discussed above. Another way to do this is to take the mathematics that students know and use it to shed light on some of the greatest discoveries of mankind as well as the mysteries of commonly-used objects and everyday phenomena.[6] Gentle Knowledge prepares material (including problem sets and solutions) around these captivating topics and gives teachers the training to effectively present them to students. Enabling students to create something nontrivial and mathematical in nature is an even more direct way to give them a sense of accomplishment. Unlike art or English, where students can paint, sculpt, or compose poetry, mathematics education has long been viewed as devoid of rewarding creative activities that can be proudly shown to others. Solving equations or adding fractions, although critically important, is rarely enjoyable. Although original mathematics research is not a realistic educational goal in school, algorithm design and implementation is. In fact, basic computer programming is the first real engineering that is accessible to students. Working programs, especially those that incorporate mathematics require a precise understanding of the underlying problem and creative effort while giving students a sense that they have built something tangible from scratch.[7] This is technology at its best. Gentle Knowledge provides teachers, even those with no previous programming experience, with material and training that enables them to give students the sense of accomplishment that has been so rare in their mathematics education.

[5] A good example of this was a recent project assigned to eighth grade students in an advanced math class that required them to write about and illustrate the existence of various mathematical objects, such as lines, curves, and circles in the real world (for instance, writing about and illustrating the fact that car wheels are circular). A major grading criterion was neatness and effort.

[6] A stunning example of this is the surprisingly accurate estimate of the circumference of the Earth by Eratosthenes in the third century BC. The mathematics required for this is easily accessible to students in middle school.

[7] Middle school students can begin to implement simple algorithms like Euclid's algorithm which finds the greatest common divisor of two integers and the Sieve Of Eratosthenes which generates prime numbers. These simple programs, only a few lines long, do not require any background in computer science or programming but do require an understanding of the underlying mathematics.

**Problem:** Every school has students that are more mathematically advanced or more interested in the subject than the rest, but often, they have few opportunities to go beyond the regular school curriculum. Although many schools have math teams and offer their students the opportunity to compete in mathematics competitions, they rarely provide these top students with courses that teach them advanced problem solving skills or other extracurricular topics. This results in missed opportunities for both students, some of whom cannot realize their full potential, and schools that lose prestigious accolades.

**Solution:** The solution to this problem creates a unique professional development opportunity and allows Gentle Knowledge to work directly with students. Members of the Gentle Knowledge team who have extensive experience participating in, organizing, and training students for various olympiads, including the International Mathematics Olympiad, run classes for both students and teachers that focus on the many nonstandard, yet beautiful and important areas of mathematics. These optional classes provide teachers who work with advanced students, both in honors and advanced placement courses, with useful teaching material and best practices. The informal and collaborative nature of these classes helps break down the unwanted boundaries that sometimes exist between students and teachers while fostering the kind of cooperation that can prove useful later on. For example, teachers that develop good working relationships with some of their top students can call on them to tutor weaker students thereby reducing a potentially excessive teacher workload.

# 4 Implementation Details

Gentle Knowledge provides three main products and services: teaching materials, in-service teacher training, and technology support. After a preliminary assessment of the constraints and challenges within a particular school or school district, and after taking into account the specific needs and requirements set forth by administrators, Gentle Knowledge recommends a course of action which can take at least one year to implement.[8] The flexibility of this approach means that many different scenarios are possible, but the following summary aims to capture most of the common essential elements.

**Teaching Material:** Gentle Knowledge has access to a wealth of original teaching materials, including problems, articles, and interactive activities, some of which have appeared in books and other publications written by team members, and some of which have never appeared in print before. After taking into account the particular sequence of topics in a school or school district, Gentle Knowledge

[8] Short-term consultation or professional development may be an option in some cases. Gentle Knowledge can also review the curriculum, textbooks, and teaching practices used in a school or school district and based on this information make appropriate recommendations or create teaching material without conducting long-term teacher training.

incorporates the relevant material at its disposal into custom teaching kits that become the basis for professional development workshops and which are subsequently used by teachers in their classes. The flexibility of this approach means that if a school teaches topic B before topic A but topic A is a prerequisite for teaching an important concept related to topic B, the teaching kit will be modified either by including the necessary background or by choosing different but equally important material. A teaching kit covering a single topic consists of the following:

- CLASS DISCUSSION MANUAL: this includes a series of problems that are sorted by increasing difficulty with full solutions, and most importantly, discussion notes that teachers can use in class. It may include warm-up problems and references to previously covered material as well as historical notes and recommended mathematics literature and films.

- HOMEWORK ASSIGNMENTS: this includes problem sets for students to do at home along with complete solutions for teachers.

- ASSESSMENT TOOLS: these are tests, quizzes, or other assignments that teachers can use to gauge student progress. Solutions are provided.

- ENRICHMENT ACTIVITIES: these are additional problems, fun puzzles, competition material, and small programming assignments that teachers can use to reinforce the class discussion material described above, to assign extra credit, or to challenge advanced students. Solutions and instructions for teachers are provided as well.

**Professional Development:** Teacher training is a critically important component in the successful use of the teaching kits described above. Because no assumptions are made about teachers' mathematics backgrounds, these professional development classes allow Gentle Knowledge team members (mentors) to go over the material, discussing both the requisite mathematics and common pedagogical scenarios that may arise in the classroom. As an additional advantage of these classes, teachers can earn Professional Development Points (PDPs) for attendance and written work.[9] Several types of classes that meet regularly (approximately every one or two weeks) are possible, all of them having the following features in common:

- PROBLEM SOLVING: teachers, working in groups, tackle the problems that are part of their teaching kits and present solutions to each other. The Gentle Knowledge mentor (a team member) in the class provides guidance, hints, and leads the discussion.

- LECTURES: if content questions arise, if a topic presents an unexpected difficulty or contains nonstandard concepts and connections, the mentor presents a short lecture on the material.

[9] Eligibility details can be worked out with the school district in accordance with state guidelines.

- TEACHER FEEDBACK: after becoming comfortable with their teaching kits, teachers can begin to use them in the classroom and can share their experience with other teachers in their professional development classes. This feedback allows Gentle Knowledge to evaluate its work and make any necessary adjustments to both the material and the training sessions.

- STRESS-FREE LEARNING ENVIRONMENT: Gentle Knowledge makes it a top priority to ensure that teachers feel comfortable with the level of the provided teaching kits and instruction. Although an effective learning process needs to challenge, teachers with stronger mathematics backgrounds are expected to help colleagues with weaker preparation.

At the request of a school or school district, Gentle Knowledge can provide additional workshops, as mentioned in section 3, that focus on training teachers to work with advanced students or that introduce basic programming into the mathematics curriculum.

**Technology Support:** Password-protected teaching kits are available online for all teachers in a school district without regard to whether they participate in professional development classes. In addition, Gentle Knowledge hosts an online forum to facilitate collaboration between teachers and to allow team members to answer any questions that may arise. This is a major cost-cutting measure that seeks to reduce the number of actual classes and workshops that need to be run, while significantly increasing the distribution of materials and best practices across multiple schools. Several other web-based solutions are currently under development.

# 5 Curriculum Details

Gentle Knowledge enriches the school curriculum by deepening the standard material, connecting disjoint topics, and introducing nonstandard ones that are both interesting and directly relevant to the principles and standards prescribed by the National Council of Teachers of Mathematics (NCTM). These nonstandard topics provide a unique opportunity to significantly broaden content knowledge while dramatically improving problem solving abilities and increasing content depth. Moreover, by incorporating this nonstandard material into their teaching, teachers will begin to narrow the gap not only between school mathematics and real world mathematics but will also make it easier for all students, not just the most advanced ones, to take part in extracurricular competitions and programs. This has been a severely overlooked area of mathematics education that has much to offer. Some of these topics and their approximate grade levels are shown below.

Table 1: Nonstandard Math Topics

| | |
|---|---|
| Grades K-5 | logic puzzles, original word problems (involving constructions, weighings, lateral thinking, and spatial reasoning), basic counting principles (combinations and permutations), number bases, mathematical games |
| Grades 6-8 | logic puzzles (involving disjunctions, conjunctions, and negations), word problems (involving unusual applications of ratios and rates), coloring and parity problems, divisibility and arithmetic with remainders, infinitude of primes, basic graph theory, invariants, pigeon hole principle, basic combinatorics |
| Grades 9-12 | logic puzzles (more involved than in earlier grades), basic number theory (modular arithmetic, Fermat's little theorem, applications to cryptography), proof by induction, proof by contradiction, inequalities (triangle, A.M.-G.M.), Pascal's triangle, extreme principle, semi-invariants, straight edge and compass constructions, geometry from a dynamical view point, geometric inequalities |

Not all of the topics shown above need to be mastered by all students. One of the main objectives of offering them is to expose students and teachers to the widest possible array of accessible mathematical tools and methods that can be studied deeply without prerequisite knowledge and without detriment to the standard curriculum. In fact, experience shows that even when these topics do not become second nature, they shed light on other core curriculum concepts.[10]

# 6 Measuring Success and Looking Ahead

Gentle Knowledge firmly believes that any education initiative needs to measure its impact as objectively as possible. Although the goals and solutions outlined throughout this document are long-term, several indicators of success become available relatively early. Because teachers are largely responsible for bringing the Gentle Knowledge approach into the classroom, they are the first to judge its impact. If teachers have a sense that their knowledge base has grown, and if they feel that the teaching kits that they receive make their jobs easier, that is one important measure of success. If students and their parents begin to appreciate the world-class level of mathematics education, and if that is reflected in improved test scores and student interest in the subject, that is another important measure of success. In the long-term, the success of this program needs to result in an increase in the number of high school graduates pursuing science, technology, engineering, and mathematics careers in college and beyond.

[10] A good example of this is the study of number bases which reinforces students' understanding of place value in the regular decimal number system.

Gentle Knowledge is devoted to improving mathematics education, yet experience shows that several other subjects can play an extremely helpful role. One of them, computer programming, is mentioned above. Creating simple computer programs and implementing simple algorithms turns out to be both simpler than a lot of school mathematics and highly educational. The obvious connections to mathematics have been mentioned earlier but beyond that, programming is becoming an increasingly more useful skill in its own right. By encouraging an activity that is inherently creative and that naturally develops problem solving abilities, schools can reinforce their mathematics programs from one more angle while perhaps even encouraging future entrepreneurs. Another natural partner in mathematics education is physics, which helps illuminate in a concrete light otherwise abstract mathematical concepts. The symbiotic relationship between these two disciplines needs to be strengthened. Finally, the game of chess provides an unexpected motivational tool in developing logical reasoning in younger students. It has proven especially successful with students with disciplinary problems and with those who are less motivated to do traditional mathematics because it encourages healthy competition that requires concentration to win. Chess has the perfect combination of simplicity (which makes it easy and intuitive to learn unlike some parts of abstract mathematics), yet it provides literally inexhaustible opportunities for problem solving and building self-esteem. Moreover, chess sets are effective manipulatives that can be used for solving a whole series of mathematical problems.[11] Gentle Knowledge seeks to bring all of these different disciplines to bear on mathematics education in the near future as part of it overall approach.

[11] A beautiful example of this is the famous eight queens problem which can be solved by children in first grade and revisited in later grades as a good exercise in algorithm design and recursive thinking.

# 7 The Team

## *Core Members*

### Victor Gutenmacher

Victor Gutenmacher is a distinguished mathematician and educator. He was a Professor of Mathematics at Moscow State University for almost twenty years and has extensive teaching experience at all levels, from secondary school to graduate school. He served as a member of the Editorial Board of Quantum (a top educational mathematics and science magazine that was later published in English by the National Science Teachers Association in conjunction with the National Council of Teachers of Mathematics) where he also organized and directed the "Teacher's Corner," a section of the magazine devoted to creating instructional materials for teachers. In addition, he served as the Chairman of the Methodology Committee for the Gelfand Correspondence School, a member of the Methodology Committee of the USSR Mathematics Olympics, a member of the Advisory Panel on the Committee for American Mathematics Competitions, and as the coach of the Soviet Team in the International Mathematical Olympiad. Dr. Gutenmacher is the author of more than 80 publications in mathematics and mathematics education, most notably the classic text *Lines and Curves*[12] which has been translated into several languages including English.

### Ilya Bronshtein

Ilya Bronshtein holds an M.A. in mathematics and a B.A. in computer science from Brandeis University. As an undergraduate he published research but has decided to devote himself to mathematics education since leaving academia. For several years he has taught extracurricular mathematics, chess, and general problem solving classes in the Brookline Public School system and has been working as a private teacher and tutor in the Greater Boston Area, applying many of the principles outlined in this document. He is also working on a software product that will be deployed in the education sector. Ilya attended the Newton and Brookline public schools and is intimately aware of the challenges and opportunities they and other American schools present.

### Tatyana Finkelstein

Tatyana Finkelstein is an award-winning mathematics teacher who has taught for over a decade in the Lexington Public School system after teaching mathematics for a decade in St. Petersburg, Russia. She is a 2006 recipient of the Distinguished High School Mathematics Teaching Edyth May Sliffe Award. Ms. Finkelstein has years of experience in teacher professional development, as a counselor in the PROMYS for Teachers program at Boston University, an intensive 6 week summer mathematics

[12] *http://www.amazon.com/Lines-Curves-Practical-Geometry-Handbook/dp/0817641610*

program for teachers, and as a participant in the Park City Mathematics Institute Secondary School Teachers Program. She has also run a summer mathematics program for middle school students in Lexploration, a Lexington-based initiative that serves surrounding communities.

**Boris Klebanov**

Boris Klebanov holds a PhD degree in mathematics from Moscow State University. He has taught mathematics at levels ranging from postgraduate studies to high school classes and summer camps for gifted elementary school students. Dr. Klebanov has also authored many publications on the topic of problem solving and olympiad style mathematics. He was the Director of the Math Circle for school students run under the auspices of the Israeli Weizmann Institute of Science and was Chairman of the Moscow Organizing Committee of the Kangaroo Mathematics Contest. Together with his students he participated in the International Junior Mathematical Congress. He has taught at the Math Circle in Boston and several of his students achieved high scores in the American Mathematics Contest and American Invitational Mathematics Examination. Dr. Klebanov has also edited several mathematics textbooks for leading US educational publishers.

**Tanya Khovanova**

Tanya Khovanova holds a PhD degree in mathematics from Moscow State University and was a gold medalist at the International Mathematical Olympiad. She is an educator, a blogger, and a popularizer of mathematics who has a keen interest in the subject of women in mathematics. Besides coaching the math team at the Advanced Math and Science Academy Charter School in Marlborough, MA she has been an organizer of the Women and Mathematics program at the Institute for Advanced Study in Princeton, NJ. Dr. Khovanova helped design the Math Alive course at Princeton University which seeks to expose those who have not had college mathematics to the concepts behind important modern applications. As a research scientist at the Council on Cybernetics under the Presidium of the Academy of Sciences of the USSR, she designed innovative educational programs in computer science for children.

## *Advisers*

### Wallace Feurzeig

Wallace Feurzeig is a Principal Scientist at BBN Technologies and a well-known researcher in Artificial Intelligence. He is an inventor of the LOGO programming language which was designed and has been used for decades all over the world as a powerful educational tool to teach children computer science and mathematics. Mr. Feurzeig has been at the forefront of research in educational technology and has authored and edited numerous books including *Modeling and Simulation in Precollege Science and Mathematics*.

### Deborah Belle

Deborah Belle is a Professor of Psychology and the Director of the Human Development Program at Boston University. She has been a chair of the Women in Science and Engineering (WISE) network and has worked to encourage girls to pursue science and mathematics careers. Professor Belle has also focused her attention on the issues surrounding poverty and inequality and the ways in which they affect children and their education. She is the author of several publications on the subject including the book *The After-school Lives of Children: Alone and With Others While Parents Work*.