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Realizing the educational promise of technology

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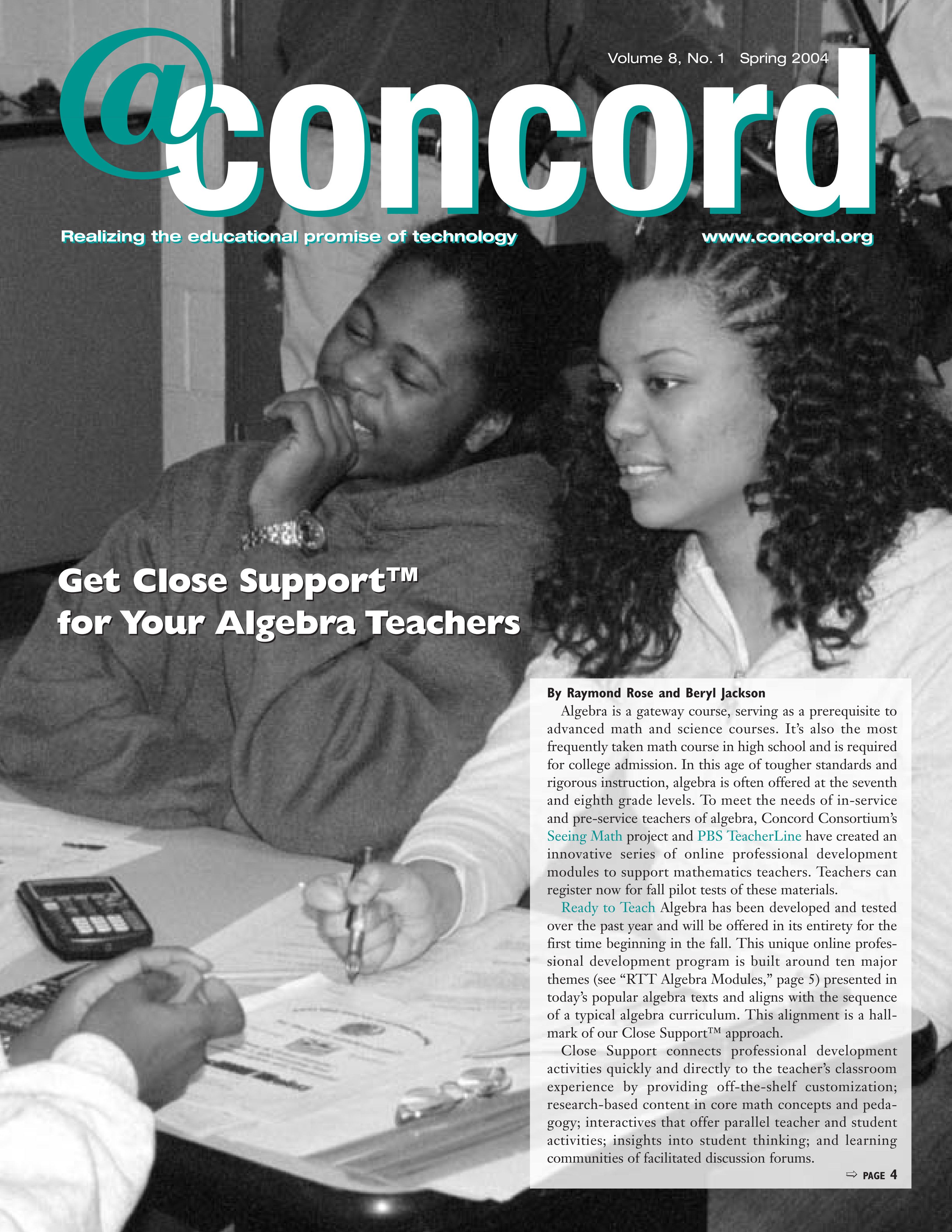

Get Close Support™ for Your Algebra Teachers

By Raymond Rose and Beryl Jackson

Algebra is a gateway course, serving as a prerequisite to advanced math and science courses. It's also the most frequently taken math course in high school and is required for college admission. In this age of tougher standards and rigorous instruction, algebra is often offered at the seventh and eighth grade levels. To meet the needs of in-service and pre-service teachers of algebra, Concord Consortium's Seeing Math project and PBS TeacherLine have created an innovative series of online professional development modules to support mathematics teachers. Teachers can register now for fall pilot tests of these materials.

Ready to Teach Algebra has been developed and tested over the past year and will be offered in its entirety for the first time beginning in the fall. This unique online professional development program is built around ten major themes (see "RTT Algebra Modules," page 5) presented in today's popular algebra texts and aligns with the sequence of a typical algebra curriculum. This alignment is a hallmark of our Close Support™ approach.

Close Support connects professional development activities quickly and directly to the teacher's classroom experience by providing off-the-shelf customization; research-based content in core math concepts and pedagogy; interactives that offer parallel teacher and student activities; insights into student thinking; and learning communities of facilitated discussion forums.

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Perspective

Celebrating a Decade

Robert Tinker

This is our tenth birthday! It's hard to believe. The Concord Consortium started in 1994 with one modest project called Hands On Physics in a tiny house in Concord, Massachusetts, that we shared with a small store. Then we were awarded two additional grants and took over the store. Now there are more than 50 of us working on a score of projects in four different locations. But the expansion is simply an outward manifestation of the growth in scope and importance of the work we do: realizing the educational promise of computer and information technologies.

Innovation is in short supply in education, at least the kind of practical innovations that help learners and teachers in new and more powerful ways. Information and computer technologies are the major enablers of innovation in all fields, but there is surprisingly little effort going into exploiting technology for education in fundamentally new ways. Most of what passes as educational technology involves recycled ideas, small applications, or impractically complex demonstrations.

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Of course, technology itself does not advance education, but no plan for improvement that overlooks the contributions of technology makes sense. Educational gains require all the resources at hand, and technology is the single most important new resource available. Unlike most educational reforms that have been tried – often repeatedly – technology brings exciting new possibilities to the table.

Computers and networks can redefine the teaching and learning experience. All the resources commonly used in education will be transformed by innovative use of technology: texts, references, libraries, lesson plans, homework assignments, illustrations, explorations, demonstrations, labs, fieldwork, quizzes, and tests. Furthermore, the preparation and work of teachers – including preservice programs, certification, professional development, text selection, lesson planning, lectures, labs, grading, mentoring, and advising – will be transformed. Such transformation will be possible because most of the supporting materials will be on networked computers and because all student and teacher creations will be digital.

Having all this online makes everything more plastic and more easily shared. Teachers can customize materials for their school and for specific students. Measures of student performance can be embedded in the materials. The technology can use the assessment data to summarize quickly student understanding so teachers can adjust their instruction. Teacher professional development can be "just in time" instead of "just in case" because it is adjusted to a participant's teaching schedule and content. Teachers can learn new ideas using tools and approaches that they can modify for use with their students. New collaborators and mentors are available online for teachers and students.

Technology offers far more than an online medium for old approaches. The content is more interactive and can have functionality that is possible

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Editor Robert Tinker
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The Concord Consortium

Technology offers far more than an online medium for old approaches. The content is more interactive and can have functionality that is possible no other way.

no other way. Graphs become something you do instead of something you observe. Probes turn computers into instruments that can measure the real world. You can play with models of atoms or galaxies, and see what happens in time scales ranging from femtoseconds to billions of years. To shed light on the real world, you can explore unreal worlds where dragons breed, light travels at 10 miles an hour, and agriculture is just being developed. Your explorations can be guided so that your learning is effective and efficient.

This combination of flexible media, tools for exploration, and online resources requires careful planning and development. No one of these technologies represents a silver bullet, but their sum total represents a new conception of teaching and learning that will be more powerful and effective. Few educators can make good use of these technologies in their raw form. They need to be combined into resources for teaching and learning that can be tested and disseminated. This is where our innovations are concentrated.

Aspects of this vision can be seen in our work reported in this newsletter. The Seeing Math project is advancing the art of online teacher professional development in a number of important ways. It is combining collaborative reflection, video case studies, and interactive software with our successful model for asynchronous, scheduled online courses. It is also experimenting with providing Close Support™ help to algebra teachers before they teach a topic and giving them software and approaches that they can use to improve their teaching.

The Molecular Workbench projects are experimenting with applying to teaching a very large and sophisticated simulation derived from approaches used in current research. The free software allows students to experiment with models of atoms and molecules that obey basic physical laws. Recent studies with students indicate that this approach allows students to gain useful insights into the molecular world. Current research is directed at using the software to learn not only physics, but also chemistry, biology, and the background needed by technicians in biotechnology and nanotechnology.

The Modeling Across the Curriculum project is studying applications of interactive models in high school science. In addition to looking for student gains as a result of specific units, the project is set up to detect cumulative gains that might result from student exposure to multiple similar models across several years. This project has pioneered the idea of capturing data from student explorations of these models and returning these data to us over the Internet. The result is very detailed research data from large numbers of students located nationwide. This approach can change the nature of educational research and, potentially, be of tremendous value to teachers.

We are deeply concerned about the special obligation we all have to provide the best possible education to every learner. At first blush, technology seems inconsistent with equity, but just the opposite is true. In the Information Age, we must ensure that the power of information and computer technology is universally available and well used.

The cost of computer hardware is not the major barrier to its use in under-funded schools. Our work has demonstrated the viability of inexpensive technologies like open source applications, Linux, and handheld computers. Under-performing schools often lack the ability to take full advantage of technology because too much of the job of integrating technology into education is left to the schools. Instead of expecting that each school fend for itself, we are providing solutions that can be scaled up to large numbers of schools.

Schools, even poor ones, will find the necessary resources, if they see that technology helps solve their instructional challenges. Before this happens, we need more technology-rich curricula to compete with texts, more applied research that can persuade skeptical decision-makers, and more proven alternatives to traditional student assessments.

We have accomplished much in our first decade and we are well positioned for the future. We are proud of our achievements over the past ten years and invite you to join us in making the next ten even more successful. @

Robert Tinker (bob@concord.org) is President of the Concord Consortium.

Close Support™ for Your Algebra Teachers

⇨ PAGE 1

Each three-week course module provides opportunities for teachers to reflect on their own learning and to identify obstacles to learning and misunderstandings through dynamic discussions with peers that support the continuous and sustained learning experience. In the first week of each module, the core algebra topic is introduced – often with an RTT Interactive (a small manipulable Java applet that is cross-platform and runs over the Internet) – to ensure that the participating teacher has a solid conceptual understanding of the math. In the second week, the teacher has an opportunity to explore student understanding of the math concept by analyzing video vignettes of classroom students and expert commentary on how students learn. Finally, the third week links teacher and student understanding to the local curriculum and presents suggestions that support the teachers in integrating course elements into their instruction.

The modular online course structure allows schools, districts, states, and even colleges and universities to offer customized sequences of the modules to best meet local needs. The sequence can be adjusted easily for schedule and length. Licensees have the option of using their own facilitators or PBS TeacherLine's professionally trained mathematics facilitators to lead the courses. Upon request, PBS TeacherLine can provide specialized facilitator training. Ready to Teach Algebra can also be used in pre-service teacher education programs as a component of middle or high school mathematics methods courses.

If you're ready to participate or are interested in more information about Ready to Teach Algebra professional development opportunities, please contact Raymond Rose (ray@concord.org) or Beryl Jackson (bjackson@pbs.org) to discuss your specific needs. @

Participants from the Pilot Study say:

- *The activities are great... they really make you re-examine the way you teach the topics in your own classes. Things like the Qualitative Grapher interactive have exciting implications for use in the classroom. The opportunity to interact with so many colleagues on a regular basis is invaluable.*
- *I am a better mathematics teacher because of the two modules we did.*
- *The course presented some basic core concepts in a very hands-on, productive way. I love the stuff.*
- *The course really helped me to be more aware of potential areas of student misunderstanding, and helped my teaching as I was taking the course.*

ARTICLE LINKS & NOTES

Seeing Math – http://seeingmath.concord.org
PBS TeacherLine – http://teacherline.pbs.org
Ready to Teach – http://rtt.concord.org
RTT Interactives – http://rtt.concord.org/interactives

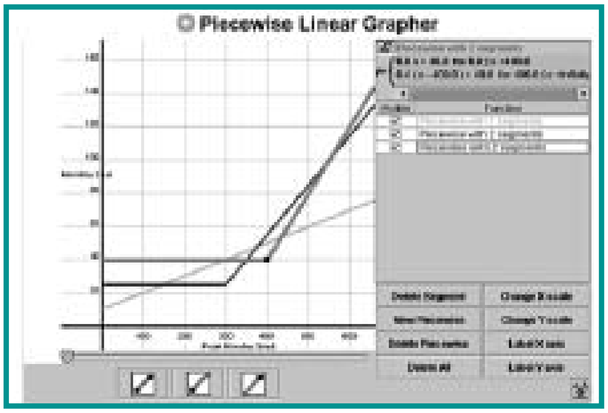
Raymond Rose (ray@concord.org) is Vice President of the Concord Consortium.
Beryl Jackson (bjackson@pbs.org) is Director of Mathematics Content for PBS TeacherLine.

Got a Plan?

In the RTT Algebra course, the goal of a problem is not only to arrive at an answer, but also to learn from the involved, sometimes messy steps in between. As you do this activity, observe your process as a teacher, an expert learner, and a problem solver. The complete "Got a Plan?" activity is available online at http://rtt.pbs.org/rtt/courses.cfm.

The Problem

Three cellular phone companies are offering promotions for new customers that are represented in the graph at right.



The cell phone plans can be represented as piecewise linear functions. The Piecewise Linear Grapher connects symbolic and graphic representations of piecewise linear functions, so that changes in one representation cause changes in the other representation.

Three users with different profiles – an attorney calling her assistant and clients from the courthouse; a retired pediatrician who makes long-distance calls to his grandchildren on weekdays; a high school math teacher who keeps in touch with her daughter's nanny during free periods and makes occasional calls to schedule appointments – each want to purchase a cell phone. They are each trying to decide which plan suits their individual needs.

Your Role in the Story

You are a customer service representative for Cell Zone, a company that produces reports on cellular phone companies and helps customers choose plans that fit their needs and lifestyles.

Your Task

As the customer service representative, you will make preliminary recommendations to your three customers. Use as many tools as you need to reach each decision and make your recommendations clear to each of your customers. Include any decisions you reach as to what plan or plans might be best suited to each of them and the conditions under which each customer might find the plan or plans most useful. @

RTT Algebra Modules

Overview

Participants learn to navigate the online course environment as they meet fellow teachers through personal web pages and online discussions. They examine obstacles to interpreting time vs. distance graphs and try out the first interactive, the RTT Qualitative Grapher. Through these activities, they examine the nature of algebra, assumptions underlying their own understanding, and approaches used in their students' curriculum.

Professional Development Goals

- Build an effective online learning community for studying algebra
- Approach learning and teaching algebra in more profound, varied, and flexible ways
- Help students interpret time vs. distance graphs correctly

Ratio, Proportion, and Scale

This module prepares the transition from a primary focus on arithmetic and skills with algorithms (typical of elementary and middle school) to a focus on algebra, where students use multiplicative, as well as additive, thinking. The common terms — ratio, proportion, and scale — are placed within the broader mathematical themes needed in algebra.

Professional Development Goals

- Understand the relationships among ratio, proportion, and scale
- Identify equivalence by comparing symbolic expressions used to express ratios and proportions
- Articulate how the concepts of ratio, proportion, and scale, although closely related, serve different purposes in expressing quantitative relationships of linear, two-dimensional, and three-dimensional measures

Linear Functions

The Linear Functions module introduces algebra through the mathematically cohesive concept of functions and grounds it by modeling real-life situations.

Professional Development Goals

- Distinguish between functions and equations
- Use piecewise functions to interpret the meaning and characteristics of linear functions in the context of real-world situations
- Identify ways that multiple representations express and enrich mathematical concepts
- Develop student activities based on module concepts

Transformations of Linear Functions

Participants observe relationships between graphic and symbolic forms of a function. They explore how changes to the graphic representation of a function alter its symbolic representation, and vice versa.

Professional Development Goals

- Observe graphic and symbolic transformations of linear functions, using interactives
- Represent, categorize, and use families of linear functions in multiple formats
- Interpret the concept of slope in different contexts

Linear Equations

Most algebra curricula introduce linear equations before linear functions. In this module functions are discussed first, showing an equation as a particular instance of a function.

Professional Development Goals

- Understand the rationale for manipulating symbols when solving problems with equalities or inequalities
- Deepen the distinction between equivalence of function and equality of value
- Gain facility in moving between symbolic and graphic techniques when solving equations, whether presented in symbolic or story (text) form

Quadratic Functions

Using models and problem solving, participants examine how the general nature of quadratic functions informs the particular instances described by quadratic equations. Participants also use multiple representations — tables, graphs, and equations — as powerful tools to describe physical situations.

Professional Development Goals

- Learn to shift from recognizing physical patterns to describing them in symbolic language, and vice versa
- Develop additional strategies for working with symbolic manipulations and syntax
- Distinguish between local and global representations of a function
- Recognize the different roles of functions and equations
- Model a variety of situations using quadratic functions

Transformations of Quadratic Functions

Using interactives, participants observe how changing symbolic expressions alters their graphic representation, and vice versa. By working with families of quadratic functions, they deepen their understanding of the role of each symbolic form in gleaning information about a function.

Professional Development Goals

- Represent, categorize, and use families of quadratic functions in multiple formats
- Understand how each of the three major symbolic forms — polynomial, product, and vertex — serve a different purpose and how each informs graphic transformations
- Execute translations, reflections, and dilations in graphic and symbolic forms
- Understand how the function notation of transformations such as $f(x)$, $af(x)$, $f(ax)$, $f(x+a)$ and $f(x)+b$ deepens knowledge about various classes of quadratic functions

Quadratic Equations

This module makes explicit the relationship between quadratic functions and quadratic equations. Because textbooks and tests devote a great deal of time to the skills of factoring and finding roots, participants also use graphical means, as well as successive approximations in tabular form, to reach the same goal.

Professional Development Goals

- Identify the three symbolic forms for quadratic equations — polynomial, product, and vertex — and clarify how each form's role informs not only its graphic representation, but also how to find the root of its function
- Delineate techniques for solving quadratic equations by comparing quadratic functions, both graphically and symbolically
- Solve quadratic inequalities, in both graphic and symbolic forms, as a natural extension of comparing functions

Descriptive Statistics

This module discusses data sets, measures of center (mean, median, mode), range and outliers, and linear fits to data sets. Research suggests that when students calculate a measure of center, they use algorithms without associating the measurement with a characterization of the entire aggregate.

Professional Development Goals

- Model and describe real-world data sets
- Connect general measures of data with the set they describe
- Understand options for characterizing large data sets
- Use measures of center and linear fit to describe particular data sets
- Use interactives to view and understand data sets in different ways

Project

This module provides a framework for project design and a set of rubrics to assess those who are taking the course for credit. It consolidates Ready to Teach concepts, participants' understanding of algebra, and their philosophies about teaching practice. Participants say farewell to their coursemates and facilitator in a brief graduation "speech." They also compose a concrete plan for using new insights in their own thinking and teaching, and learn from the plans of colleagues.

Monday’

Modeling

By Boris Berenfeld, Amy Pallant, Barbara Tinker, and Qian Xie

It’s a fact of life – we all carry around mutations: random changes in the sequence of nucleotides that make up our DNA. While some mutations can cause diseases such as Sickle Cell Anemia, others may simply contribute to the more subtle variations that make each living being unique. Mutations encompass various changes to the DNA sequence caused by substitutions, deletions, and insertions of the nucleotides. DNA determines the sequence of amino acids in proteins. That sequence, in turn, determines the shape of each protein and its biological function. Mutations sometimes change the shape and function of proteins. The molecular basis of this chain of causation is challenging to teach.

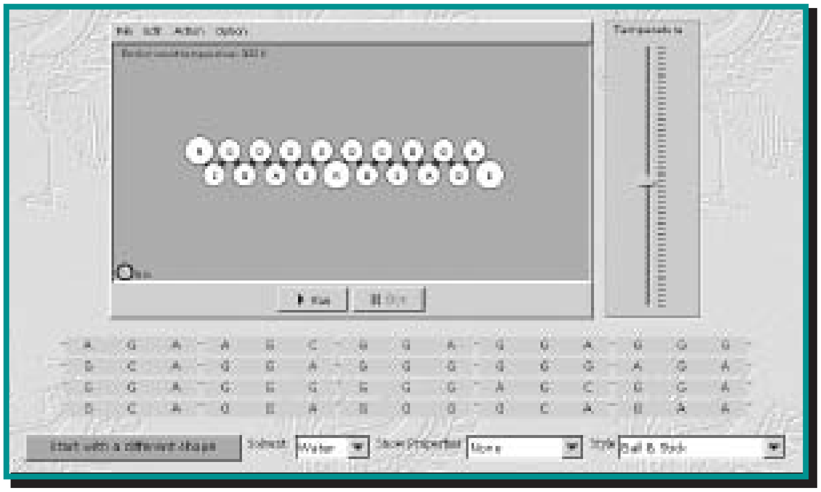


Figure 1. A view of the Mutations model. The 20 amino acids in the chain are connected to the genetic "keyboard" below it. Students can change or delete any nucleotide in the keyboard and observe possible changes in the sequence of the amino acids and the changes in the way the chain folds.

An NSF-funded project, the Molecular Workbench, is completing a study (see “Notes from the Molecular Classroom” on page 8) of how a molecular dynamics model, embedded in relevant learning experiences, can help students reason about how changes in DNA might have implications for protein function.

At the heart of this activity lies a computational model. In the smallest fractions of time, the computer makes many millions of calculations prescribed by the model, and displays on the computer screen new configurations of molecules in response to a student’s intervention. Contrary to traditional animations whose interactivity is usually limited to pressing the “Start” and “Stop” buttons, dynamic models allow students to conduct experiments at a molecular level and follow their own lines of inquiry.

For this Monday’s Lesson we present a short activity in which students use a model to explore interactively the relationship between DNA and the shape of the protein for which it codes. A complete set of activities with lesson plans is available at:

http://workbench.concord.org/web_content/

Launch the Model

To open and run the *Mutations: Substitutions and Deletions* model, go to http://xeon.concord.org:8080/modeler/webstart/protein/mutations.jnlp in your web browser. The software will launch automatically. A simplified two-dimensional molecular dynamics model approximates protein folding in different environments. The white beads represent amino acids connected by peptide bonds and the blue background represents the water in which the polypeptide chain is floating. Connected to the peptide chain is a genetic “keyboard,” which allows students to generate mutations in the DNA and thereby affect the sequence of the amino acids in a protein for which this part of the DNA is the genetic code.

With this model, students can control the amino acid sequence by replacing amino acids in the model protein or by altering the sequence of the nucleotides in the corresponding string of DNA. They also can change properties of the surrounding media (from vacuum to water or oil). Working with the model, students learn the correspondence between the sequence of nucleotides in a strand of DNA and the sequence of the amino acids in a protein, and explore in real time how changes they make in the genetic code affect both the sequence of amino acids and the shape of the model protein. See Figure 1.

System Requirements

The Java Runtime Environment (JRE) of Java 2 Platform, Standard Edition (J2SE) v1.4.1 or higher version must be installed on your computer in order to run the Molecular Workbench model. Windows or Linux users can download it from Sun Microsystems website. Mac OS X users can update to the latest Java through the Software Update pane of the System Preferences of their computers.

’s Lesson

Mutations

The Activity

A. Substitutions

1. Begin by clicking the cursor on the run button and running the model.
2. Note the model forms a “flying bird” pattern.
3. Change the first G of the third codon (GGA) in DNA to A, making the codon AGA.
   - To change a nucleotide, point the cursor towards it. Now left-click (on a PC) or hold-click (on a Mac) to open a pull-down menu.
   - Select a new nucleotide.
   - When you make a nucleotide mutation, the corresponding amino acid in the protein window will blink in yellow.
   - You can look at the different properties of the new amino acid by selecting “charge” or “hydrophobicity” from the “Show Properties” menu.
   - You can view the name of the amino acid by pointing the cursor to the amino acid and holding the “Alt” (Option key on a Mac) key while left-clicking the mouse. A bullet in front of its name identifies the amino acid.
4. Click “Run.” Describe what happens, if anything, to the shape.
5. Now make three changes in the sequence of DNA by randomly substituting any of the nucleotides with another. Record what nucleotide you changed (for example, “In the fifth codon, I changed the first nucleotide from A to T.”) and describe how the replacement affected, if at all, the shape of the protein.
6. Explain why some substitutions of nucleotides in the DNA appear to have no effect on the protein.
7. Explain how one critical substitution of the nucleotides in the DNA can have a significant effect on protein shape.

B. Deletions

1. Reload the model by clicking the reload button in the menu bar.
2. Change the sequence of DNA by deleting the third nucleotide. Click “Run.”
3. Describe what happens to the shape of the protein.
4. The original protein sequence is:
   R-S-G-G-G-A-G-G-G-R-G-G-G-S-G-R-G-G-R-E
   Record the new protein sequence.
5. What happens to the DNA code after you deleted the third nucleotide?
6. Which type of mutation has the greater effect, substituting a nucleotide or deleting one? What might explain this difference?

Getting at the Root of Sickle Cell Disease

In this activity students work with the critical segment of the hemoglobin’s protein to explore the effect of the mutation in the DNA leading to Sickle Cell disease. They generate single point mutations leading to the replacement of the anionic glutamic acid with non-polar valine. This is exactly the amino acid substitution that causes Sickle Cell disease. Students can then learn how such mutation affects the hemoglobin conformation. They also learn how this mutation can help protect a carrier from malaria. Try this yourself at: http://xeon.concord.org:8080/modeler/webstart/protein/hemoglobin.jnlp

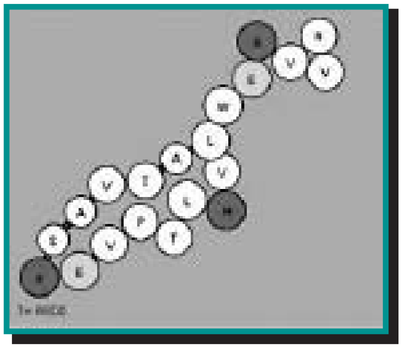


Figure 2. The portion of the hemoglobin protein that contains the Sickle Cell mutation, as rendered in the Molecular Workbench model.

Educational Significance

The model cannot predict the actual protein conformations for a large molecule – this is still an open research question – but it does illustrate how changes in temperature, charge, or surrounding medium can change the shape of a protein. It also allows students to explore the relative role of different mutations on the shape of a protein and predict how various mutations (substitutions, deletions, insertions) affect the function of proteins and why, for example, in most cases deletions are lethal for a cell. This model provides students with a manipulative, dynamic tool that could develop their intuition about basic interactions affecting protein folding, and allows students to observe in real time how changes they make in the genetic code affect both the sequence of amino acids and the shape of the model protein. @

Boris Berenfeld (boris@concord.org), Amy Pallant (apallant@concord.org), Barbara Tinker (barbara@concord.org), and Qian Xie (qxie@concord.org) are members of the larger Concord Consortium molecular modeling team.

ARTICLE LINKS & NOTES

Molecular Workbench – http://workbench.concord.org

Molecular Workbench activities and lesson plans – http://workbench.concord.org/web_content/

Java Sun Microsystems – http://www.java.com/en/download/manual.jsp

Notes from the Molecular Classroom

The goal of the Molecular Workbench projects, funded by the National Science Foundation, is to provide a rich environment that makes the atomic level familiar, predictable, and connected with the macroscopic world, and to understand the effect of such an environment on student learning. Keep up with our research and software in these short announcements and see our website for additional information.

Improved Learning, Improved Software

Adapted from "Genetic Code to Protein Shape Using Dynamic Modeling," by Boris Berenfeld, Amy Pallant, Barbara Tinker, Robert Tinker, and Qian Xie, submitted to *Biochemistry and Molecular Biology Education*.

Analysis of data from the Molecular Workbench project reveals that high school biology students learn well when they explore and interact with a dynamic model of protein code and shape. Interviews conducted with students several months after the activities were implemented suggest that students maintain a strong mental model of this content long after the activities were introduced.

Molecular Workbench materials – including a computer model and the related "From DNA to Protein Conformation" curriculum unit (see below) – were tested in six classrooms in three suburban high schools in Massachusetts. In all classes, students scored significantly higher on the post-test than the pre-test. For instance, students regularly employed the ways in which specific amino acid properties (e.g., charge and hydrophobicity) help describe the interactions of the different amino acids with each other and with the solvent. Additionally, students correlated how a change in the sequence of DNA could have implications for protein function and, in some cases, for human health.

From DNA to Protein Conformation

This four-part unit offers the following scaffolded learning activities:

- Activity One – How a Protein Gets its Shape: Charged Amino Acids
- Activity Two – How a Protein Gets its Shape: Interacting with Water or Lipids
- Activity Three – How a Protein Gets its Shape: The Role of DNA
- Activity Four – Protein Malfunction and Disease

Students manipulated a computer model, built on a powerful computational "molecular engine." With simple computer keystrokes and mouse clicks, students modified a model amino acid sequence. For example, they substituted and deleted nucleotides in the DNA, and observed the effects on the sequence of amino acids and the spatial organization of the protein. Students worked with a model segment of Sickle Cell hemoglobin. (See "Monday's Lesson: Modeling Mutations," page 6, for a similar activity.)

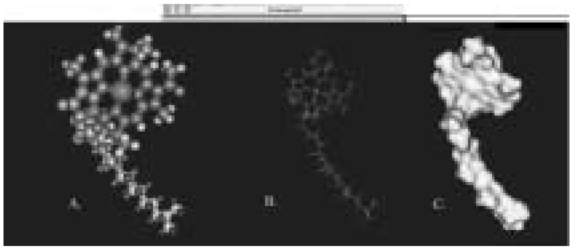


Figure 1. Teachers and students can explore a large molecule such as chlorophyll – the basic pigment of plants' photosynthetic system – from various perspectives, starting with traditional "atoms and bonds" view (A) to its carbon skeleton (B) or a surface view (C).

The Molecular Viewer

Our 3D Molecular Viewer software is currently in development. This powerful and user-friendly software is written in Java and is cross-platform (Windows and Mac OS); it is designed to work with other software, including the Molecular Workbench. The Molecular Viewer is translated into five languages.

With the Molecular Viewer, users can explore preloaded molecules or download PDB (Protein Data Bank) files from the Internet, and view the molecules in a variety of representations, including color coded by individual atom and surface view (see Figure 1). The software is equipped with an interactive Periodic Table (which plays "periodic" music tunes!) and an amino acid reference data-table.

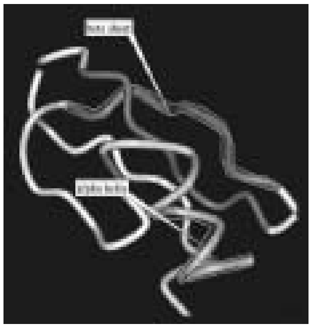


Figure 2. An annotated image in the Molecular Viewer (tube view of trypsin).

The Viewer also allows students to add notations to the molecular images, and save them for assessment or further reference (see Figure 2).

Molecular Workbench Drawing Tool and Arbitrary Shapes

Adapted from "Molecular Dynamics Simulations Beyond the Lennard-Jones Model," by Qian Xie and Robert Tinker, submitted to the *American Journal of Physics*.

Biological shapes are organic; they need to "breathe" as they move. Recognizing the difficulty in building an analytical model for interacting particles with arbitrary shapes that is also computationally efficient, we developed a drawing tool in Molecular Workbench, which permits users to draw arbitrary non-self-crossing shapes, such as rectangles, ellipses, cubic splines, or free-form curves.

When the user finishes drawing a shape, Lennard-Jones particles are automatically aligned along the line if the shape is open, or along the border if the shape is closed, to its full length. After the alignment is completed, harmonic forces are used to connect the LJ particles in radial and angular directions, to combine them into a single object.

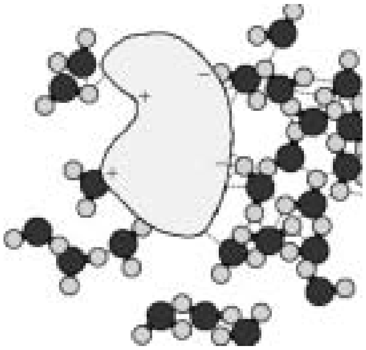


Figure 3. A molecular dynamics simulation of intermolecular interactions in aqueous solution. The smaller circles represent hydrogen atoms, the larger, oxygen atoms; and the kidney-shaped object represents a macromolecule. The plus and minus signs on the macromolecule signify that it is polar. The dotted lines show the hydrogen bonds. Such a simulation may help students understand how water mediates chemical reactions between proteins.

Such an object has a van der Waals surface that can attract (and be attracted to) other similar objects or LJ particles. It also has a border that is formed by the repulsive core of the Lennard-Jones potential to prevent overlaps with another object or LJ particle. If an atomic probe were used to scan over the border, an enveloping shape would be created, because the repulsive cores push back on the probe. In molecular biology, such an enveloping shape generated by a real or hypothetical probe is called a molecular surface.

A molecular surface object is not a rigid body. Its shape vibrates and can be distorted. The harmonic forces used to bind the LJ particles form a "spring chain" that maintains the shape. The rigidity of the shape rests on the strength of the harmonic forces.

The molecular surface object models a macromolecule (e.g., proteins) in a simplified way. It captures the essential idea that the surface of a macromolecule is generally far more important than the interior in facilitating intermolecular interactions and active site reactions. For example, a MD simulation for the intermolecular interactions of macromolecules in aqueous solution, in which the macromolecules are represented by molecular surface objects (see Figure 3), shows clearly the interactions between the charged sites and water molecules around them.

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Molecular Workbench Software: Additional Enhancements

Recent work on the Molecular Workbench software has also enhanced its capacity by increasing the number of objects, including amino acids (see Figure 4), and building in the ability of authors to annotate their models, as well as build full activities around the models. The software authoring interface, designed for non-programmers, allows the user to insert interactive models (not just molecular simulations) and their supporting interactive components, such as bar graphs, sliders, buttons, text boxes, tables, and so on, into a word processor. The word processor hosting environment also offers the user a full set of traditional text editing functions (including the ability to insert images and add hyperlinking, for example). A chemistry engine has been added and activities using the engine are being written in WISE, the learning environment developed at the University of California at Berkeley.

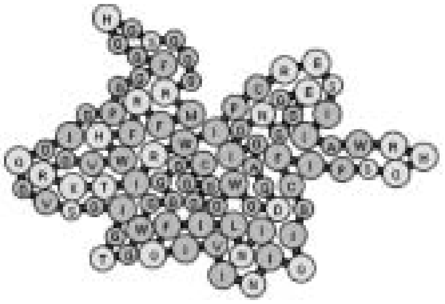

Figure 4. A folded conformation of a 94-residue protein in an aqueous solution. The light beads represent hydrophobic amino acids. The darker beads represent hydrophilic amino acids. The black lines between two adjacent beads represent peptide bonds. The hydrophilic amino acids tend to be found on the exterior of the protein structure, where they make more contacts with water molecules.

Molecular Workbench Workshops

The Molecular Workbench projects offer workshops for secondary and college level science educators on using and authoring with their software. A workshop is planned for June 24-25 at the Concord Consortium in Concord, Massachusetts. If you are interested, please contact Barbara (barbara@concord.org). @

ARTICLE LINKS & NOTES

Molecular Workbench – http://workbench.concord.org

WISE (Web-based Inquiry Science Environment) – http://wise.berkeley.edu/

Tips from TELS: Advice for Blended Courses

By Alese Smith

The Concord Consortium is a founding member of the Technology Enhanced Learning in Science (TELS) project, a research consortium sponsored by the National Science Foundation. Each year of the five-year project, TELS faculty offers a collaborative online course to students at each of the participating institutions. The first course on Assessment and Technology, offered in spring 2003, enrolls graduate students from UC Berkeley, Arizona State University, Norfolk State University, Boston University, North Carolina Central University, Pennsylvania State University, and Technion Institute of Technology, Israel.

The TELS course is a unique blended course, delivered online and with face-to-face sessions, with the distinction of being led by local instructors in each of the seven locations. Each weeklong online unit of the course has students in each locale interacting mid-week in face-to-face sessions with their local instructors and classmates. This stimulating arrangement has led to the creation of communities of learners in both the local settings and on the larger scale of 16 to 20 online students.

As we prepare for our next course offering in fall 2004, we reflect on our learnings to date, and we invite you to sit in on our musings and examine a few of our successful strategies.

Remember the Learners

Education is always about the students. We must be open to listening to students as they progress through each of our online courses, and never assume our experience trumps theirs. Each new student reaction, suggestion, and criticism is as valuable as any from the online course pioneers. We must be open to new students and to experienced online learners, who bring with them skills and expectations that can help us challenge our notions about how best to construct online communities. Best practices must be flexible enough to change as we continue to learn with and from our students.

Keep It Simple

Our students have the advantage of many sources of interaction, including discussions and small group work with local and online instructors and classmates. The course must be structured in a way to help students feel supported and organized; students must not spend valuable online time with unnecessary navigation of the courseware. Students should focus on the learning, with the technology transparent. The courseware should not drive the course. Instead, course needs should come first, with the courseware forced to meet those needs.

Create Inclusive Discussions

Although we assign a variety of discussion activities for our students and feel structure and order are essential scaffolding to encourage online discussions, we want to focus on student learning, not on checkoffs of how many postings each student has made each week. Combining discussions on several related topics may help students feel more connected as they study readings each week, share their life experiences, and reflect on the comments of their classmates.

Commit to Asynchronous Communication

For students learning English, online conversations often work best, allowing students the necessary time to

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One Intern's Experience

By Ayisha Fullerton

When I first learned about the TELS online course on Assessment and Technology through Dr. S. Raj Chaudhury of Norfolk State University, I was eager to participate, though my initial excitement was tempered: online learning was new to me and I really didn't know what it entailed. The online course took some getting used to. Navigating through pages of text was intimidating at first, but I was determined, and with the help of fellow students and the support of the instructors, I was able to keep up each week.

Soon, everything was smooth sailing in the course. Each weeklong lesson introduced new topics in technology and assessment, including ethics, reliability, validity, and enhanced assessments. As an aspiring physics teacher with little teaching experience, the most valuable aspect of the course was the opportunity to interact in the discussion boards with teachers and students with varying levels of teaching experience. I was able to learn from their experiences with classroom assessment and to share my own ideas in a truly collaborative environment.

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research confusing expressions their classmates use and to phrase their comments carefully. For teams that use fast-action online chats or conference calls, those without a strong English background may find the process frustrating and alienating.

In a Blended Course, Pull People Online

The lure of the face-to-face segment of blended courses is an attraction that's capable of pulling conversations out of the online discussions. It's a challenge to keep students from saving their questions and best comments for the next face-to-face class. To avoid this pitfall, online conversations must include clear guidelines and expectations, and a strong and timely instructor involvement with students. Additionally, private online discussion areas afford students individual counseling, encouragement, and answers to any questions they might be feeling uncomfortable asking in front of the group.

Make the Instructor Voice Constant and Clear

With multiple instructors determining the readings and activities each week, it's difficult for students to keep track of whose voice is that of the online instructor. Although we provide weekly content experts who serve as discussion leaders, we like to keep a reliable constant in the voice of the instructor – the clearly identified and introduced personality who presents the online information each week and answers questions. This person serves as "the" instructor to oversee the entire course program.

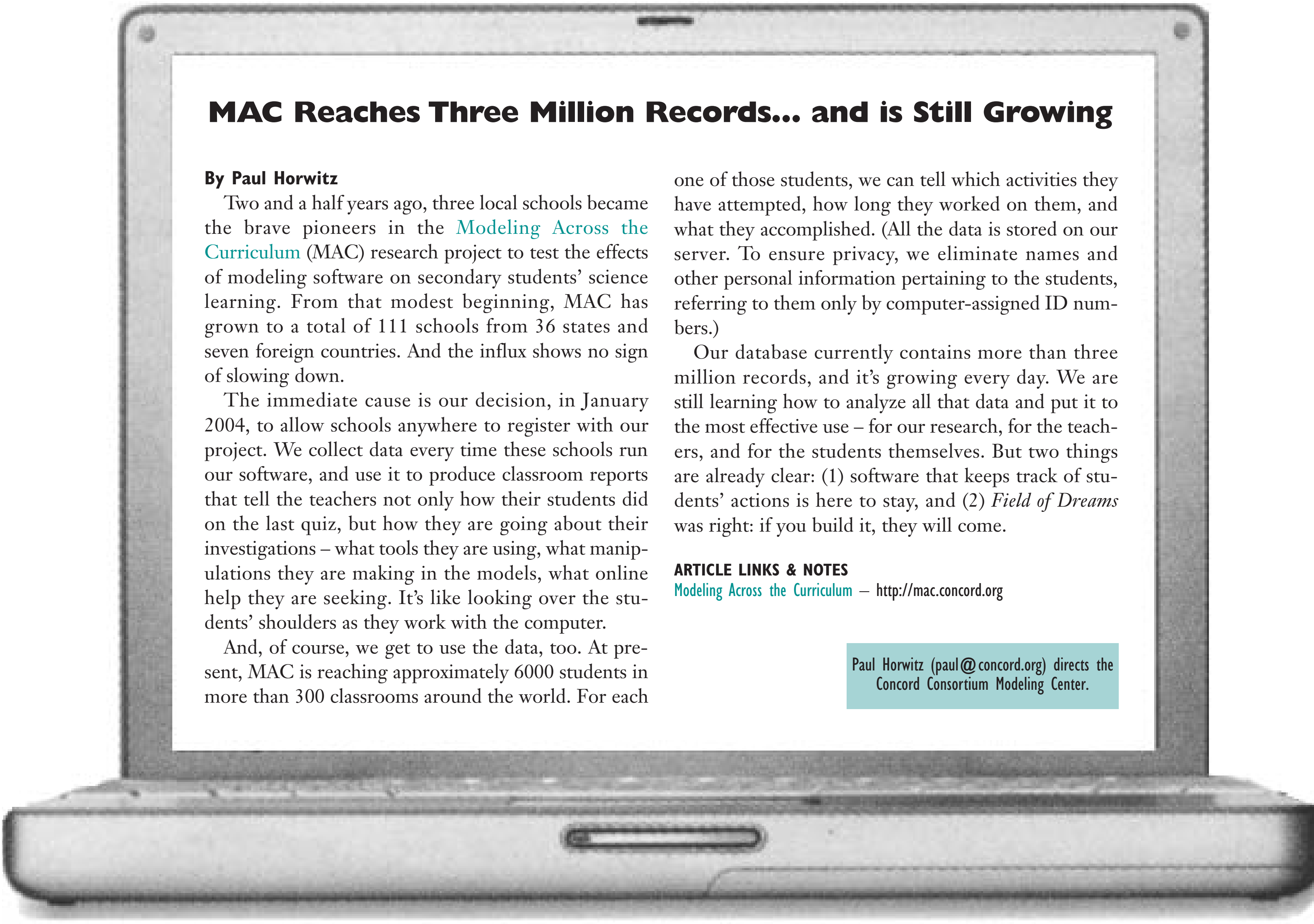
Go Deep, Not Broad

The best learning comes in the form of mastering a limited number of concepts in depth, rather than many concepts at a minimal level. Online and blended courses can accomplish this by presenting focused readings, research, and discussions, and not spending students' time with many unrelated assignments.

In the fall, we'll offer our next TELS course, incorporating learnings from this and our other online projects. For more information or to become involved, visit the TELS website.

ARTICLE LINKS & NOTES

TELS – http://telscenter.org



MAC Reaches Three Million Records... and is Still Growing

By Paul Horwitz

Two and a half years ago, three local schools became the brave pioneers in the Modeling Across the Curriculum (MAC) research project to test the effects of modeling software on secondary students' science learning. From that modest beginning, MAC has grown to a total of 111 schools from 36 states and seven foreign countries. And the influx shows no sign of slowing down.

The immediate cause is our decision, in January 2004, to allow schools anywhere to register with our project. We collect data every time these schools run our software, and use it to produce classroom reports that tell the teachers not only how their students did on the last quiz, but how they are going about their investigations – what tools they are using, what manipulations they are making in the models, what online help they are seeking. It's like looking over the students' shoulders as they work with the computer.

And, of course, we get to use the data, too. At present, MAC is reaching approximately 6000 students in more than 300 classrooms around the world. For each one of those students, we can tell which activities they have attempted, how long they worked on them, and what they accomplished. (All the data is stored on our server. To ensure privacy, we eliminate names and other personal information pertaining to the students, referring to them only by computer-assigned ID numbers.)

Our database currently contains more than three million records, and it's growing every day. We are still learning how to analyze all that data and put it to the most effective use – for our research, for the teachers, and for the students themselves. But two things are already clear: (1) software that keeps track of students' actions is here to stay, and (2) *Field of Dreams* was right: if you build it, they will come.

ARTICLE LINKS & NOTES

Modeling Across the Curriculum – http://mac.concord.org

Paul Horwitz (paul@concord.org) directs the Concord Consortium Modeling Center.

Inside @concord for Spring 2004

1. Get Close Support™ for Your Algebra Teachers

Ready to Teach Algebra professional development modules provide Close Support for teachers of mathematics. Learn how you or your school district can participate.

Realizing the educational promise of technology

2. Perspective: Celebrating a Decade

The Concord Consortium celebrates ten years of realizing the educational promise of computer and information technologies.

6. Monday's Lesson: Modeling Mutations

With the Molecular Workbench model, students explore interactively the relationship between DNA and the shape of the protein for which it codes by examining the mutation responsible for Sickle Cell Anemia.

8. Notes from the Molecular Classroom

High school biology students learn with the Molecular Workbench model; Molecular Viewer software makes 3D visualizations possible; new drawing tool and improved authoring environment for Molecular Workbench.

10. Tips from TELS: Advice for Blended Courses

Technology Enhanced Learning in Science, which offered its first course on Assessment and Technology, shares advice for blended courses.

11. MAC Reaches Three Million Records…and is Still Growing

Halfway through its five-year funding period, the Modeling Across the Curriculum project reaches 6000 students in more than 300 classrooms worldwide.

Concord Consortium News

Balanced Assessment – The Balanced Assessment in Mathematics Program, housed at the Harvard Graduate School of Education for ten years, is now located at the Concord Consortium. The library of over 300 mathematics assessment tasks developed during the project remains freely available for teachers to use in their own classrooms. Reports on the Balanced Assessment approach to mathematics assessment and the distinctive objects × actions scoring system are available. Print publications produced by the Balanced Assessment program can be purchased through the Concord Consortium.
http://balancedassessment.concord.org

TEEMSS 2 – Technology Enhanced Elementary and Middle School Science project (TEEMSS2) has been funded by the Instructional Materials Development program at the NSF (Grant # IMD0352522). This two-and-a-half year, $2.7M project is developing and testing probeware-based science curriculum and software for grades 3-8. We plan to work with all the major vendors of probeware. We jumpstarted our efforts by hosting nine of the major probe developers (CMA Coach Probeware, CPO Science, Data Harvest, Fourier-Systems, ImagiWorks, PASCO Scientific, Texas Instruments, and Vernier Software & Technology) for an initial vendors' meeting in January 2004.
http://teemss2.concord.org

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