

@concord

Realizing the educational promise of technology

www.concord.org

Free Computer-Based Learning Resources

We are delighted to be able to offer a growing collection of free software and student materials that use this software. Through grants from the National Science Foundation and the U.S. Department of Education, we have produced a number of innovative software packages and incorporated them into hundreds of powerful learning activities, each tested in real classrooms. Whatever you teach, at whatever level, we have software-based learning activities that can improve your teaching. Our strengths are in science at the secondary and college levels. We also have algebra software and sustainable development materials that can be used across disciplines and grade levels. Visit our [Software Download Center](#) to get access to these great materials.

This special issue of the newsletter features a number of activities based on our free software. It includes five hands-on lessons for you to use in your classroom. "Monday's Lesson" has been a regular feature of this newsletter that demonstrates one way our materials can be easily implemented in a classroom. This has been such a popular column that we are expanding it in this issue to include five lessons, named for each weekday. Of course, you can use them on any day of the week! The lessons are not intended for sequential use for a particular discipline; instead they highlight the variety of activities available from the exciting work at The Concord Consortium.

Perspective

Creating the Educational Golden Gate Bridge

Robert Tinker

If we only aspired to build bridges over small rivers and streams, we would have no Golden Gate Bridge, which affects the lives of tens of thousands of people every day. To improve education, we need far more national investment on the level of an educational Golden Gate Bridge. As a country that relies heavily on innovation, the U.S. seems strangely averse to educational innovation that could have a national impact. This aversion is undermining our future.

The United States acts as though there is something special about U.S. education that guarantees that it will continue producing plenty

of creative, well-trained graduates regardless of educational policies. But the advantage that the U.S. has is thin and perilous. Indeed, the only advantage is in education at the elite undergraduate and graduate level, and that is at

permanently lose the economic advantages that it currently enjoys.

The U.S. does fund pre-college education by as much as \$460 billion annually, or \$9,350 per child, and the federal share of this is about \$35 billion, or about \$700 per child, mostly to subsidize schools or disseminate best practices. However, very little of this goes toward the development of innovative materials that might actually improve student learning nationwide. Current statistics show that the development of tested educational innovations receives as little as \$2 per child or less than 0.03% of the total spent on education. There is probably no other sector of the U.S. economy that invests such a small percentage of its effort to innovation or applied research. In contrast, the pharmaceutical industry invests 23% of its income in innovation, a relative investment that is 700 times larger than education spends.

We must apply to education the same rigorous approach used in science research. There are two kinds of research, academic

and applied. The goal of academic research in education is to develop new insights about learning. This is an important endeavor, but not one that is required to improve U.S. education; we already know enough to make huge gains in teaching and learning. Applied research, on the other hand, is needed to determine whether a particular innovation leads to increased learning for certain kinds of students in various school environments. Applied research is often overlooked and underfunded, but it is an essential part of educational innovation.

Investing in innovations that have proven value has a huge payoff because the resulting materials can be used in any classroom. It is, for instance, well within our capacity to increase student learning by providing free online, innovative, classroom-ready materials for every K-12 subject and grade for a total cost of roughly \$11 per child, or 0.12% of one year's expenditure. These are tiny amounts, yet the impact would be dramatic and lasting. Of course, this

We must apply to education the same rigorous approach used in science research.

risk because funding is not keeping up with costs. U.S. pre-college education, particularly in the areas that prepare students for high-tech careers, is in crisis. U.S. student performance in math, science, and technology is only average in international comparisons.* U.S. education appears to have some advantage in terms of stimulating creativity and risk-taking, but other countries are closing those gaps as well. Unless the U.S. invests intelligently in education, it could

@concord

Editor Robert Tinker
Managing Editor Cynthia McIntyre
Design Pointed Communications

@concord is published twice a year by the Concord Consortium, a nonprofit educational research and development organization dedicated to educational innovation through creative technologies.

Copyright © 2004 by The Concord Consortium. All rights reserved. Noncommercial reproduction is encouraged, provided permission is obtained and credit is given. For permission to reproduce any part of this publication, contact Cynthia McIntyre at cynthia@concord.org.

The projects in this newsletter are supported by grants from the National Science Foundation (REC-0115699, ESI-0242701, DUE-0402553), and the U.S. Department of Education (R286A000006). All opinions, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the funding agencies. Mention of trade names, commercial products, or organizations does not imply endorsement.

If you wish to change your subscription information, please clip the mailing label from this newsletter, indicate the changes and mail to:

The Concord Consortium
10 Concord Crossing, Suite 300
Concord, MA 01742

You also may call 978-369-4367 or fax 978-371-0696.

You can access your account or sign up for a free subscription online at www.concord.org/members.

Note: We do not make our mailing list available to other organizations.

As a nonprofit organization, the Concord Consortium has no ongoing support for @concord. Contributions to defray printing costs would be greatly appreciated.

Visit our website at www.concord.org for information on projects, services, courses, and free software.



The idea that education could be improved through free computer-based materials sounds fantastic, but only in the context of the current inadequate support of educational technology. It is easily within grasp.

investment alone will not improve education; coordinated teacher professional development and support for technology would be required, but even if these cost several times as much as the research and development costs, the totals are trivial compared to the total cost of education.

If you survey all the kinds of innovation that might have the greatest impact on education, technology plays a central enabling role. New modeling environments can provide simpler ways for students to understand difficult concepts. Probeware greatly improves lab experiences. Online courses make high quality professional development courses available anywhere, anytime. Handheld computers put inexpensive, portable computers in students' hands. Online curriculum materials can be economically distributed and easily modified. Assessment embedded in online materials can give teachers an analysis of student learning with unprecedented detail and currency. Networking supports all kinds of collaborations that can invigorate learning. Online resources provide detailed information on every possible topic.

I am deeply concerned with the lack of support for educational technology and the lagging recognition of its educational value. The Concord Consortium specializes in technology-

based innovation and we are proud of the advances we have made, some of which are described in this newsletter. But these successes only hint at the potential. There are many exciting possibilities that are not being pursued.

We could have extensive, proven computer-based curricula. These could take advantage of research-grade models like our Molecular Workbench. The materials could be easily modified to fit the needs of teachers at different grades in different contexts. Detailed assessments could be gleaned from student use of the materials, giving teachers and researchers detailed data about student learning and material effectiveness. Some versions could be more open-ended and others more guided. Accessibility by students could be assured through run-time modifications that are made automatically or by a teacher. Some of the software could run on inexpensive handheld computers that can exchange data with a classroom server. And it can all be made freely available through open source systems.

The result would be a huge increase in learning at all levels and disciplines. Because the materials were free, they would be a force for equity, even in the face of the digital divide. Providing the extensive teacher professional development needed to exploit the advantages of computer-based materials

would be a larger challenge. There is already large-scale funding for disseminating innovations, largely through professional development; this would have to be expanded and focused more on the integration of technology.

The idea that education could be improved through free computer-based materials sounds fantastic, but only in the context of the current inadequate support of educational technology. It is easily within grasp.

Educational innovation is currently like an amateur sport; every teacher and school is urged to innovate, to figure out how to integrate technology, and to assemble a curriculum. It is important to foster this kind of spirit, because it enriches a classroom. But large-scale innovation that can be disseminated nationwide requires professional teams of educators, developers, technologists, researchers, and designers. Instead of exclusively relying on federally funded block grants to states and schools, a larger fraction of funds should be retained at the federal level to create innovations that will improve every school. Just as we rely on professionals to build bridges, we need to use professionals to create educational innovations that could fully exploit the value of technology to improve education. @



Robert Tinker (bob@concord.org) is president of The Concord Consortium.

ARTICLE LINKS & NOTES

* See <http://nces.ed.gov/timss/results.asp#mathscience1999>

Free Computer-Based Learning Resources

⇒ PAGE 1

Handheld Computers



We have long advocated educational uses of handheld computers, because they provide an affordable alternative to full-sized computers. Handhelds are not only as good as larger computers in some situations, their portability makes them superior for field studies. (See *Monday's Lesson: Handheld Computers in the Field* on page 6.)

Science of Atoms and Molecules

The Molecular Workbench is a sophisticated model of the interactions among atoms and molecules. Learning activities based on this model help clarify what is happening at the atomic level and have been used with all the sciences and engineering from middle school through college. The Molecular Workbench model is embedded in a special word processor, so you can build your own activities.



The easy-to-use activity building tool handles text, one or more models, buttons and other controllers, graphs and other model outputs, and student response areas, which makes it easy to create your own model-based learning activity for students. Over

100 learning activities have been created by us and by teachers like you, and are cataloged in an online database. (See *Tuesday's Lesson: Making Molecular Models Your Own* on page 8.)

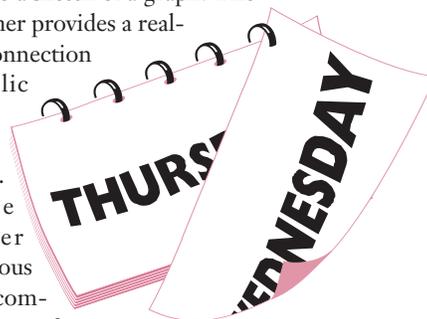
Another simple authoring environment is **WISE**, developed by our collaborators Jim Slotta and Marcia Linn at Berkeley. WISE allows you to make activities or modify ones that others have made. An activity is constructed from a series of steps. Several dozen types of steps are available; each step can be customized by filling in an online form. Steps can include a Molecular Workbench, BioLogica, or Dynamica model, allowing anyone to build and deliver a complete Web-based lesson that uses our models.

Pedagogica

For the more technical, our Pedagogica programming environment supports the scripting of Java-based applications, such as BioLogica or Dynamica. The authoring tool includes a graphic interface for specifying screen layouts, and a simple node-and-arc interface for navigating the scripts. Pedagogica also supplies a run-time environment that allows the scripts to communicate with the applications and a logging manager that keeps track of students' interactions with the software.

Algebra Interactives

We are developing online courses for algebra teachers that include a collection of simple software packages called **interactives** that each focus on one key mathematical concept. For instance, the Qualitative Grapher challenges the user to connect motion to a sketch of a graph. The Linear Transformer provides a real-time, two-way connection between symbolic and graphic representations of linear functions.



The Piecewise Linear Grapher extends the previous ideas to graphs composed of pieces of straight lines. The Function Analyzer relates three representations of linear functions, including one based on area. The Quadratic Grapher allows students to explore the relationship between symbolic and graphic representations of quadratic functions. (See *Wednesday's Lesson: The Starburst Activity* on page 10, and *Thursday's Lesson: Warming Up to Quadratics with the Parabola Web* on page 12.)

Environmental Education

Our Center for a Sustainable Future has developed three software packages designed to get students thinking about the future and how they might



use global resources. The What-If Builder is a writing tool for short stories that have many different outcomes, depending on what the reader selects. It both delivers such stories and lets students author and share them. The Community Planner is a simplified spatial modeling and visualization tool that allows students to create a map of a neighborhood, town, or community, and analyze the map based on indicators that they can help define. The Ecological Footprint Calculator estimates how much land is needed to sustain the user's lifestyle and how many earths would be required if everyone had the same consumption patterns. Our **database** includes over 60 tested activities related to sustainable education for grades K-12, many of which use this software. (See *Friday's Lesson: Using the What-If Builder* on page 14.)

In addition to the software showcased in the following five lessons, we have developed other software packages and associated student materials that you can access from the Software Download Center.

BioLogica is a model of genetics built on various inheritance patterns at the level of molecules, genes, and individuals. Growing out of a decade-plus research program, many know the software by its earlier name: GenScope. Students can learn from open-ended exploration of the model or by working through a series of scaffolded learning activities.

Dynamica is a model of classical Newtonian mechanics in two dimensions. Inspired by ThinkerToys, a popular package that ran only on the Commodore 64, this modern version is perfect for introducing vectors, kinematics, and dynamics in physical science and beginning physics courses.

VideoPaper Builder2 is a tool jointly developed with TERC for the development of multimedia video case studies of teaching. A VideoPaper consists of video, captions, a narrative about the video, and artifacts, such as lesson plans and student work. VideoPaper Builder simplifies the work of synchronizing and indexing the various elements. The software links various models, generates menus, framesets and slide shows, and organizes the imported files as an HTML document viewable in a web browser. The resulting VideoPapers are a great way to stimulate thoughtful discussion about teaching and learning. VideoPaper Builder3, which will include new features and a simpler user interface, will be available soon.

Under Development

We are currently creating additional applications to extend the utility of our growing collection of software. For instance, we already have a wonderful program for probes and sensors called CCProbe. It collects real-time data from a variety of sensors and runs on handheld computers as well as full-sized ones. Unfortunately, CCProbe only works with archaic hardware we created for a past project. We are expanding the capacity of CCProbe and interfacing it with a number of commercial probeware packages.

We are adding random mutations and a population level with environmental pressures to BioLogica and linking

this to the Molecular Workbench. The result will be a mechanistic model of molecular evolution forced by the environment.

We are also experimenting with using inexpensive Webcams to capture images and then processing those images to track automatically a moving object. Like the motion detector, this will give real-time data, but for two-dimensional motion, and the equipment will be less expensive.

All of our software is copyrighted under one of the open source licenses. This means that anyone can have access to the source code and make changes to it. We believe that open source is a strategy for long-term support of this software. Because the majority of our work is grant-supported, when the grant runs out, our ability to support the software ends. But when a community of educators uses the software, it is in the interest of all members of the community to maintain and improve it. Become part of the community by using this free, high quality software, and enjoy the lessons in this newsletter! @



ARTICLE LINKS & NOTES

Software Download Center — <http://www.concord.org/downloads/>

WISE — <http://wise.berkeley.edu>

Ready to Teach Algebra Interactives — <http://rtt.pbs.org/rtt/interactives.cfm>

Center for a Sustainable Future database — <http://csf.concord.org/esf/index.php?module=curriculum&type=unit&func=view&order=theme>

Robert Tinker (bob@concord.org) is president of The Concord Consortium.

MONDAY'S LESSON

Handheld Computers in the Field

When students do projects in their own backyards, neighborhoods, and playgrounds, they make real-life discoveries. And when handheld computers team up with database and spreadsheet software, students can turn the collection of real-life data into actual fieldwork, and become math and science experts about phenomena in their local community.

Creating a field guide is a great way to learn about the environment, and leave a lasting legacy. The following lesson describes some of the powerful portable software that can be mixed and matched to fit different needs and budgets. Even though this lesson took place in Denali, Alaska, it can be adapted to your local geography and data collection needs.

Denali National Park Fire Succession Study

The **Denali National Park and Preserve** encompasses six million acres of pristine wilderness. This sub-arctic ecosystem hosts grizzly bears, wolves, Dall sheep, moose, and a biosphere reserve filled with forests, glaciers, and a wide variety of plants and vegetation.

In June 2004, the Eastern Area Fire Management of the National Park Service and Denali Borough School District



Figure 1. Campers used a field guide on handheld computers to identify plants and animals.

collaborated to study fire succession. The **Denali Science and Storytelling Camp** offered teachers and students in grades 4-12 an opportunity to use handheld computers to investigate the diversity and catalog the changes in the park after a fire.

Fire succession studies research the natural recovery and development of forest vegetation following wildfires. This involves counting the plant species that either survive fire intact or are capable of colonizing the immediate post-fire site from seed sources. Because succession is a natural and recurrent process of developing forest vegetation, understanding its basic features is essential to the effective management of the park. Natural wildfires, mostly caused by lightning, are a critical component of the boreal forest ecosystem. Fires of considerable size and intensity have created a patchwork landscape of vegetation communities of different species and ages. The Denali Camp participants set about studying and recording the landscape of three burn areas.

Campers' Fieldwork

All of the technology the Denali Camp participants used and the types of data they collected can be adapted to any location. Let's take a look at how the campers created a field guide and how a similar project can be accomplished anywhere.

Armed with lightweight, portable Zire 71 handheld computers with built-in digital cameras, the campers visited several burn sites, ready to photograph and identify the plants and animals of interior Alaska, and create their own specialized field guide. With a handheld version of **SmartList**, camp participants identified plants and animals using a common field guide for reference (Figure 1). Then they added a description and photograph to each entry. They also recorded numbers of plant species in a fire effects plot spreadsheet.

Next, participants measured the temperature and depth of the permafrost at each burn site with **Vernier** direct-connect temperature sensors using the **ImagiWorks** sensor interface and **ImagiProbe** software (Figure 2). Although this may sound daunting, the equipment is simple and intuitive to operate, and it can be used to record temperature data in rivers and lakes, or on land.



Figure 2: Portable technology can capture the local ecosystem.

To record data, students used **Sheets To Go**, which is part of the **Documents To Go** software created by Microsoft (Figure 3). It allows students to collect data in the field on a handheld computer and then export it to a Microsoft Excel spreadsheet.



Figure 3. Participants used software on their handheld computers to collect data.

Collecting Data

Students followed a common protocol to accurately collect a species cover count. To do this, they followed a 20-meter straight line, or transect, and half a meter on the right side of the transect line they looked for species every meter. When a species was located, it was identified and entered on the spreadsheet (Figure 4).

After returning from the burn areas, the handheld computers were synced with a laptop and data was downloaded to determine the species cover count and the overall percent coverage.

Ask Yourself!

Using a handheld computer, students can create a digital field guide to their neighborhood. When thinking about what to record, ask these questions:

What conditions threaten my local ecosystem?

What plants and animals live here?

How do they live?

What changes do I see?

A field guide project does not have to be as big as a national park. What's in your local community? Is there a playground, a neighborhood park, or a stream where students can collect data? Is there someplace where conditions are changing or the land is threatened?



Figure 4. Participants follow a transect and record data in the field.

From Data Collection to Poetry

In addition to using the handhelds to collect data, camp participants used their creative talents to design animations about the concept of fire succession (Figure 5) using software called *Sketchy*.



Figure 5. Participants design animations about fire succession using *Sketchy* software.

Based on this animation, another student wrote the following poem to describe the natural cycle that occurs as the forest returns.

*One flame dropped
there it burns
Down to ashes
then it turned*

*Up sprouts life
a whole new world
Repeating the cycle
the forest returns*



Wireless Technology

Denali campers also tracked wolves using Global Positioning Systems (GPS). Handheld GPS units are widely available and

can be used to record the locations of animals, plants, or even people!

Students used a secure digital (SD) card in their handhelds to access the National Wildlife Federation Handheld Guide to Birds and used it to identify the local Alaskan birds. This comprehensive guide includes field marks, bird sounds, and seasonal migration marks.

Participants also used *Isight* software, a wireless connection supported by towers mounted atop several mountains, and Wireless Fidelity (Wi-Fi) cards in portable computers throughout the park as a method to transfer live video to those not in the field.

Investigating Your Community

With the help of handheld computers and some easy-to-use software, students can create a field guide, track animals, even investigate something that threatens the local ecosystem.

Contact your local park service or environmental agencies for research ideas and assistance with field study protocols. Visit the *Usight* website for more information on how handheld computers can be used as tools for data collection and more.

The possibilities are as wide as the imagination. @

ARTICLE LINKS & NOTES

Denali National Park and Preserve — <http://www.nps.gov/dena/>

Denali Science & Storytelling Camp — http://www.teachingsstory.com/denali/science_story_camp.html

SmartList — <http://www.dataviz.com/products/smartlisttogo/>

Vernier direct-connect temperature sensors — <http://www.vernier.com/probes/probes.html?temp-group&template=temperature.html>

ImagiProbe — <http://www.imagiworks.com/Pages/Products/ImagiProbe.html>

Documents To Go — <http://www.dataviz.com/products/documentstogo/>

Sketchy — <http://goknow.com/Products/Sketchy/>

Isight — <http://www.apple.com/isight/>

Usight — <http://usight.concord.org/>

Carolyn Staudt (cstaudt@concord.org) works for the Concord Consortium on many projects. One of Carolyn's passions is data collection using handheld computers.

TUESDAY'S LESSON

Making Molecular Models Your Own

The Concord Consortium's Library of Models includes over one hundred models and activities to enhance students' understanding of molecular interactions. Created in the Molecular Workbench software, these models illustrate a variety of topics, including solutions, chemical reactions and protein folding.

But what if you have your own ideas about how students should experience these models? For instance, maybe you want to connect a model to a lab your students have done, or you want to assess student understanding with different questions. Perhaps you feel the pedagogical approach would not be familiar to your students. What if you are working with non-English speaking students and would like to use the models in your classroom?

In this lesson, we use the Molecular Workbench's authoring environment to transform a simple model of salt dissolving in water into a structured exploration of the dissolving process. We save pages, edit text, insert questions, and create and share student reports (Figure 1).

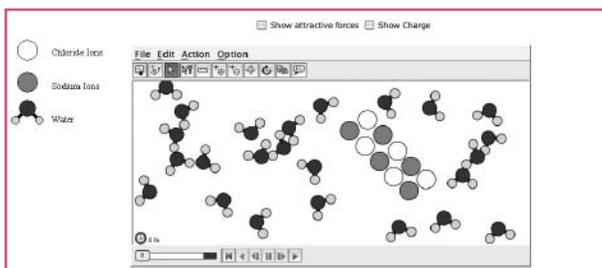


Figure 1. The Molecular Workbench model not only models particles, but allows an author to toggle on charges and other attractive forces, including van der Waals forces.

Selecting the activity

First, download Molecular Workbench from:
<http://xeon.concord.org:8080/modeler/index.html>

Go to the Library of Models. Select Water Molecules and Solution, then Dissolving Salt in Water.

Saving pages to your computer

To edit existing Molecular Workbench activities, you must first save them onto your computer.

1. Create a new folder on your desktop and name it Dissolving. Any images or files we include in our activity must be saved in this folder.

Database of Models

A database of Molecular Workbench models is available at <http://molo.concord.org/database>. Search by standards, textbook chapters, modules, concepts, or stepping stones. Look for models marked "Workbench Editable."

2. From the file menu in the top left of the Molecular Workbench screen, choose "Save" and save the file into the folder you just created.
3. The page now includes an "Editor" button in the toolbar. Click the Editor button to put the software in editor mode. Notice the options available to you, including fonts and formatting options similar to a word processing program, like bold and italics. And that's just the beginning!

Adding and removing text

Let's add two pieces of text: a description of the model and instructions for students.

1. Remove the existing text around the model. Click your mouse to the right of the model, then tap the keyboard's left arrow once. This will move the cursor to the left of the model (and to the right of the text box). To remove the "Key Concepts" text box, press the backspace key (left arrow on Mac).
2. Remove or edit the text below the model by highlighting the text you want to edit or delete, and pressing the delete key on your keyboard. You can type new text here, if you like. Note: Be careful not to remove the model or the model controls. If you accidentally delete something, use the "Undo" option in the edit menu.
3. In this space below the model, type a description of the model. Use the options in the toolbar at the top of the page to change the font style and format.
4. Press the Enter (Return) key on your keyboard to move the cursor down. From the Insert menu, select Text Box. A popup box allows you to use HTML formatting. Or simply type over "Your text" in the main text field. Add instructions to your students on how to conduct an experiment with the model, and click OK when finished.

Inserting images

Images or screenshots can be added to your activity. For instance, you might like to add a key to remind students what each atom represents. (Remember that your image must be saved in the Dissolving folder you created earlier.)

1. Click your cursor where you would like the image to appear.
2. From the Insert menu choose "Picture," then "From File."
3. Navigate to your saved image, and click "Select."

Inserting questions

You can generate questions for your students to answer after they've experimented with the model. For this activity we are going to add a text field for students where they can type their response.

1. To insert an open-ended question, click the cursor in the desired location.

- From the Insert menu, chose "User Input Text Area." Set the size of the response box in terms of rows and columns (or leave the default settings).
- Type your question into the caption text area, overwriting the existing title there.
- Click "OK."

Creating student reports

Molecular Workbench allows users to generate reports that include responses to questions as well as screenshots of the current state of the model (Figure 2).

- Select the location for this "activity button." When clicked, this button will open a new page that includes responses to activity questions. It will also display an option for the user to save a screenshot of the model.
- Place the cursor where you want the button to appear. From the Insert menu, choose "Activity Controller" then "Activity Button."
- A box appears that lets you set the button text. In the pop-up box under "Select an action," use the menu to choose "Create a report about this page in a new window." Give the button a short name in the Text field. Choose a background color and border, if you like.
- Click "OK."

Figure 2. A student report generated by Molecular Workbench includes the student's choice of screenshot of salt as it is being dissolved. Questions and the student's answers are appended beneath the screenshot.

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 [Java Sun Microsystems](http://www.java.com/en/download/manual.jsp). Mac OS X users can update to the latest Java through the Software Update pane of the System Preferences of their computers.

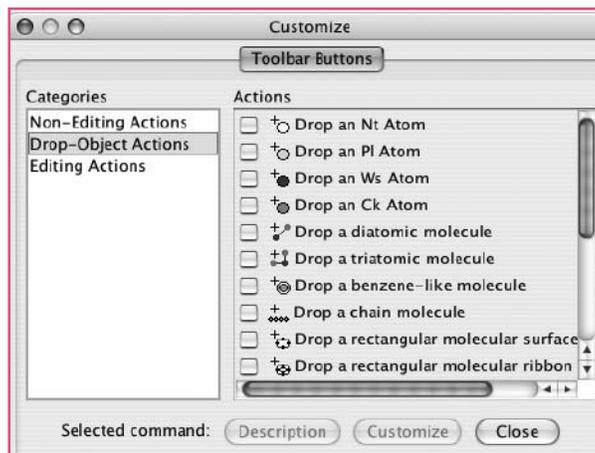


Figure 3. With the Molecular Workbench customization tool, an author can add objects and actions for students to use in their exploration of a model.

Sharing what you have done with others

Upload your activity to a database of activities to share with other users, including your students.

- Save your page.
- From the Collaboration menu, choose "Upload Current Page." Click Yes on the disclaimer box that informs you that your activity will be saved to a public website.
- Enter information about the model, including your name, student level (e.g., elementary or high school), and a description of the model. Select "Model" for type.
- Click the Submit button.
- User-created activities can be found in the online database: <http://molo.concord.org/database>

Advanced: changing or creating a model

Once you have mastered the editing system, you might be inspired to change a model or create a new model (Figure 3). With the Molecular Workbench software, the possibilities are endless. @

ARTICLE LINKS & NOTES

Instructions for software installation can be found at: <http://molo.concord.org/software/>

[Java Sun Microsystems](http://www.java.com/en/download/manual.jsp) — <http://www.java.com/en/download/manual.jsp>

An online User's Guide for Molecular Workbench can be found in the Molecular Workbench software under the Help menu or by going to: <http://xeon.concord.org:8080/modeler1.3/tutorial/preface.cml>

Jeanette Boles (jboles@sch.ci.lexington.ma.us) is a chemistry teacher at Lexington High School in Massachusetts, where she fell in love with the Molecular Workbench models.

WEDNESDAY'S LESSON

The Starburst Activity

Mathematics is a tool that models the relationships we see in everyday life, and many of these relationships can be described by functions. For example, a situation as simple as an after school job that pays \$7 per hour can be described symbolically by the linear function $y = 7x$.

There is power in looking at functions in different representations – words, numeric (or tabular), symbolic, and graphic – and understanding that a change in one is mirrored by a change in the others. Once students practice comparing representations and observing the connections between them, they are less likely to rely on point-by-point graphing every time they encounter a new function. And they are more likely to ultimately understand how functions can model real-world problems.

Comparing Representations

The Starburst activity below focuses on comparing changes in the graphs of linear functions with corresponding changes in the symbols used to describe them. Students can gain

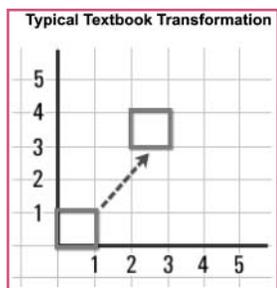


Figure 1. Typical Textbook Transformation.

This transformation develops skill in interpreting Cartesian coordinates. It leads students to focus on changing a set of points, rather than on moving the object itself.

Transformations of Linear Functions

To transform a linear function, students must shift their perception. They must view the graph of the function (a line) as an object.

Often when they are asked to graph two different linear functions, such as $y = 2x$ and $y = 2x + 3$, students start by identifying a few values of the function (values of y) for a few input values (values of x), then list them in a table and graph each function. When they do this, students see the functions as unrelated to each other. However, the functions $y = 2x$ and $y = 2x + 3$ are related: the line that represents the graph of the function $y = 2x + 3$ is simply the graph of $y = 2x$ moved up 3 units.

The Starburst Activity

How does changing the slope of a line change the symbolic expression of the function? How does changing the symbolic expression (or equation) “move” the graph of the function on the coordinate plane?

The Concord Consortium’s interactive tool called the Ready to Teach (RTT) Linear Transformer (Figure 2) gives students the power to change different representations of a function and then instantly observe what happens. In the

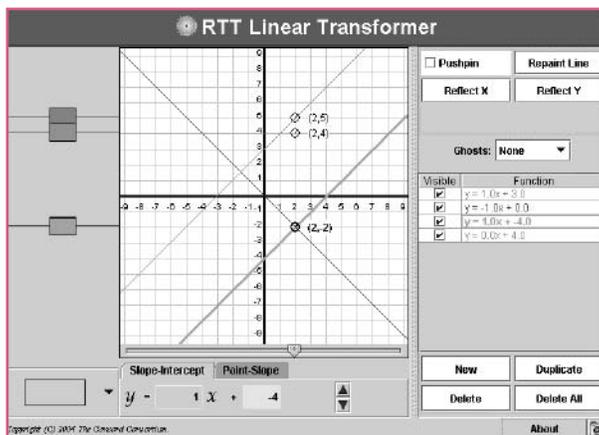


Figure 2. RTT Linear Transformer.

Starburst activity, students can use the Linear Transformer to observe the relationships between different representations of a function by manipulating the functions that make up a “starburst” pattern.

Getting to Know the RTT Linear Transformer

Give students a chance to familiarize themselves with the software before doing the activity.

To access the Linear Transformer, go to: <http://rtt.pbs.org/rtt/interactives.cfm>

Note: You need Java 1.3.1 or higher to run the interactives. Check your Java by using the RTT wizard (<http://rtt.concord.org/Wizard>), or install or update Java Software for the Desktop (<http://java.com>).

Open the Linear Transformer and explore the features.

1. Make a line.
2. Grab the line, move it, and watch how the equation that describes the line changes.
3. Make another line. Notice the color coding.
4. Change values in the symbolic expression of the line and observe how the graph of the line changes.
5. Explore the *Reflect* feature.
6. Explore the *Pushpin* feature.
7. Experiment with other features. When you are satisfied that you understand how the Linear Transformer works, try the challenges below.

Challenge 1: The Starburst

Using the Linear Transformer, make the starburst pattern (Figure 3). All lines intersect at the origin (0,0).

Hint: The angles do not need to be equal.

- Write the equations of the lines that make up the starburst pattern.
- Which elements do the equations have in common? Which elements are different?

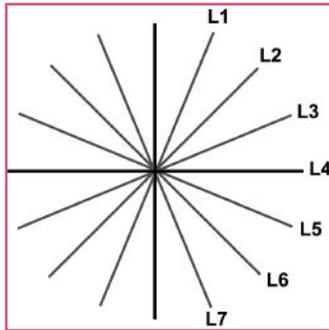


Figure 3. The Starburst.

Challenge 2: Lift the Starburst

Make a similar starburst pattern in which all the lines intersect at the point (0, 4) (Figure 4).

- Write the equations of the lines that make up this starburst pattern.
- Compare the equations of the lines in this starburst to the original starburst. Which elements of the equations are similar? Which are different?

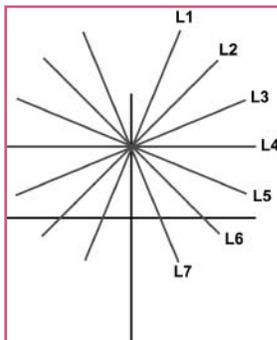


Figure 4. Lift the Starburst.

Challenge 3: Shift the Starburst

Make a similar starburst pattern in which all the lines intersect at the point (4, 2) (Figure 5).

- Write the equations of the lines that make up this starburst pattern.
- Compare these equations to the original starburst. Which elements are similar? Which are different?
- Which form of the equations did you find most helpful in doing these challenges (slope-intercept or point-slope form)? Explain.
- While working through these activities, when did you choose to manipulate the symbolic or graphical representations?

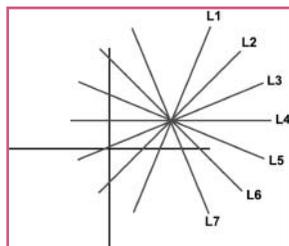


Figure 5. Shift the Starburst.

Challenge 4: Make Your Own Starburst

Describe how you would make a starburst pattern anywhere on the coordinate plane.

Extensions to the Starburst Activity

Giving students new challenges can help you gauge your students' observations and understanding. Here are a few examples:

1. Write the equations that make up a starburst pattern that passes through (-2, 0). Try it first without graphing. Then test your prediction by making the pattern on the Linear Transformer.
2. Write the equations that make up a starburst pattern that lies in the third quadrant.
3. Make the diamond pattern (Figure 6).

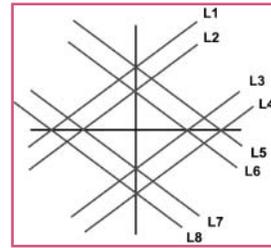


Figure 6. Starburst Activity Extension.

In the Classroom

Though students were not asked explicitly to discuss or define variables or unknowns in this activity, they explored different ways to express functions symbolically and graphically. This activity, especially through the use of the Linear Transformer, highlights two very common conceptual hurdles:

- Distinguishing between a *variable* (a quantity that changes) and an *unknown* (a fixed quantity)
- Knowing when to use different symbolic forms to represent a linear function: slope-intercept ($y = mx + b$) vs. point-slope ($(y - y_1) = m(x - x_1)$)

Have students use the Linear Transformer to explore different forms of a linear equation. Encourage them to observe the relationships between the symbolic and graphic representations.

Once they have had many experiences comparing different representations of functions, students will be better equipped to generalize about the characteristics of linear functions. @

ARTICLE LINKS & NOTES

Ready to Teach — <http://rtt.concord.org>

Ronit Carter (rcarter@concord.org), George Collison (gcollison@concord.org), and David Pinzer (dpinzer@concord.org) are members of the Ready to Teach content development team.

THURSDAY'S LESSON

Warming Up to Quadratics with the Parabola Web

Learning a new technology while grappling with new concepts or skills can be confusing. Getting students comfortable with the technology first makes it easier for them to focus on the learning, rather than on the tool. A common strategy is to simply allow students to play with the new tool for a few minutes before starting an activity. A different approach

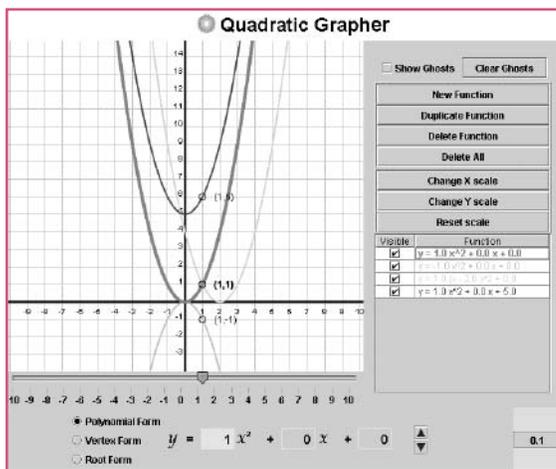


Figure 1. The RTT Quadratic Grapher allows students to explore the relationship between the symbolic and graphic representations of quadratic functions.

is to take students through a structured exploration, or “software warm-up.”

The Ready to Teach (RTT) Quadratic Grapher (Figure 1) allows students to explore the relationship between symbolic and graphic representations of quadratic functions. The Software Warm-Up introduces students to the Quadratic Grapher and its features. The warm-up is designed to get students thinking about

the ways that changes in the symbolic representation of a quadratic function mirror the changes in its graph (a parabola) and prepare them for an activity we call the Parabola Web.

Software Warm-Up: The RTT Quadratic Grapher

To access the Quadratic Grapher, go to:
<http://rtt.pbs.org/rtt/interactives.cfm>

Note: You need Java 1.3.1 or higher to run the interactives. Check your Java by using the RTT wizard (<http://rtt.concord.org/Wizard>), or install or update Java Software for the Desktop (<http://java.com>).

The first part of the warm-up familiarizes students with the features of the Quadratic Grapher and emphasizes making observations.

Warm-Up 1: Try It and See

1. *Quadratic Equation.* Locate the symbolic expression at the bottom of the screen. This is the symbolic representation of a quadratic function. What function does the program show when it opens?
2. *The Slider.* Move the slider (the inverted triangle at the bottom of the graph). What does it do? Use the slider to find the vertex of the starting parabola and a few points on it.

3. *New Function.* Click the “New Function” button and you’ll see a new parabola. Where did the first one go? In the table on the right-hand side, can you tell which expression represents which parabola? What happens to a parabola when you click on its graph? Or when you click on its expression in the table?
4. *The Equation.* Look at the symbolic expression at the bottom of the screen. Click the box in front of x^2 (the coefficient) to select it. Notice what happens when you click the up and down arrows a few times. Which parabola changes? How?
Choose a parabola you want to change (by clicking the corresponding color in the table at right). Click the box in front of the x term to select it. Notice how the parabola and the symbolic expression change when you click the up and down arrows a few times. Do the same with the last box (the constant term). What do you notice now?
5. *Experiment.* Use the other buttons. Each time you try a new button, see what changes you notice – in the parabola, in the symbolic expression (at the bottom), and in the table (at right). Watch what the slider does, too. (There is a lot to notice – look around!)

Warm-Up 2: Make It and Check It

The second part of the software warm-up lets students glimpse what the Quadratic Grapher can do. The warm-up hints at software features and tasks that students will need for the Parabola Web activity, but avoids revealing the “Aha!” moments that the activity is designed to generate.

1. Make three parabolas whose vertices are all on the y -axis. What do their symbolic expressions have in common?
2. Make two parabolas that are mirror images of each other. What do you notice about their symbolic expressions?
3. Graph the parabola $y = 2x^2 + 8x + 4$. What are the coordinates of its vertex? (*Hint:* There are two ways check if you are correct. What are they?)
4. Graph the parabola $y = 2(x - 4)^2 - 8$. Then graph another parabola that crosses the x -axis at the same points as that parabola does. Compare the vertices of these two parabolas.
5. Make a parabola with its vertex at $(12, 0)$. Use the “Change x Scale” button. Use the “Duplicate Function” button to make another parabola that has a different vertex, but crosses the original parabola. Then find the intersection point(s). (*Hint:* How can the slider help you?)

The Parabola Web Activity

In *Wednesday's Lesson: The Starburst Activity* (page 10), you transformed linear functions. The Parabola Web activity is based on the same idea – transforming a family of functions on the coordinate plane – but this time it's quadratic functions. Now that students have done the warm-up activity, try out the real thing.

Challenge A: Comparing Graphs and Symbols

Look at the Parabola Web in Figure 2. All the parabolas pass through $(0, 0)$. The function rules that describe each parabola have the form $y = ax^2$, where a is a constant.

1. Use the Quadratic Grapher to help you write the function rule for each of the parabolas in the web. Now, look closely at the rules, and in the following problems, try to figure out how the coefficient of x^2 (the letter a) is related to the graph of the corresponding parabola.
2. Write a function rule to describe a parabola with the same vertex, whose other points lie somewhere between parabolas A and B.
3. Write a function rule to describe a parabola that looks like parabola B reflected about the x -axis.
4. Write a function rule to describe a parabola that looks like parabola D reflected about the x -axis.
5. How does the number you choose for the coefficient of x^2 (the letter a) change the shape of a parabola? Write your conclusions and explain your reasoning.

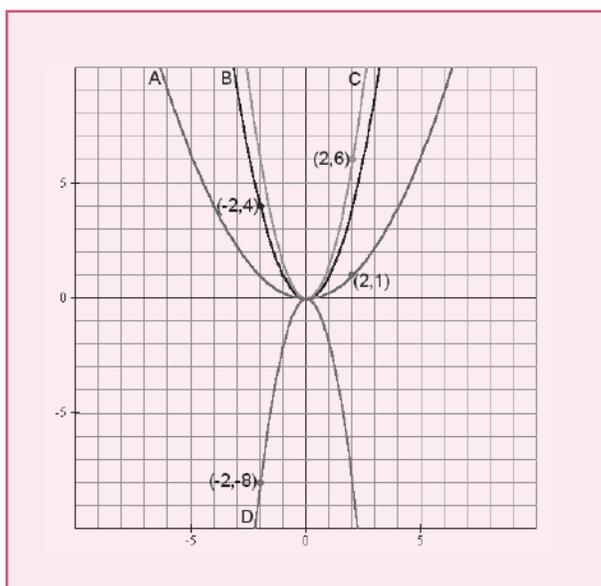


Figure 2. This family of four quadratic functions forms a “parabola web.” The function rules that describe each parabola have the form $y = ax^2$, where a is a constant.

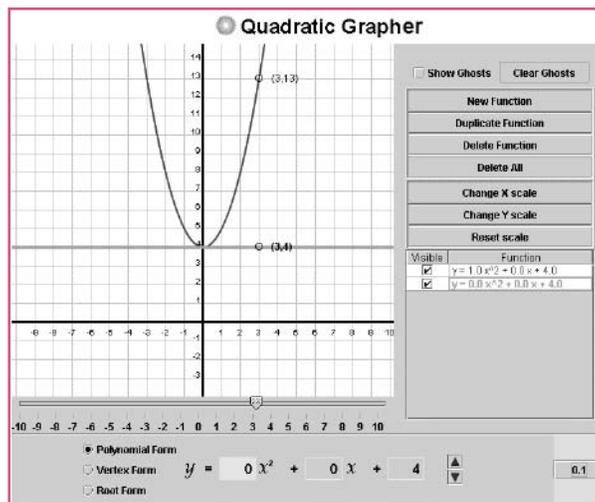


Figure 3. The Quadratic Grapher challenges students to think about the graph of a function described by a symbolic expression in the form $0x^2 + bx + c$, highlighting the difference between linear and quadratic functions.

Challenge B: Moving the Parabola Web

The parabolas in Challenge A form a web with vertices at $(0, 0)$. Try moving them.

1. Show how you would move the vertex of each parabola from $(0, 0)$ to $(0, 1)$ by changing the function rule. Moving a graph in this way is called a *vertical translation*.
2. Show how you would move the vertex of each parabola from $(0, 0)$ to $(2, 0)$. Moving a graph in this way is called a *horizontal translation*.
3. Show how you would move the vertex of each parabola from $(0, 0)$ to $(-1, 2)$. Demonstrate and explain your reasoning using one of the parabolas. How does the function rule for the parabola change?

From Seeing to Understanding

The Quadratic Grapher is a powerful tool that helps students see what is difficult to show on paper. For example, a fundamental difference between linear and quadratic functions is the x^2 term – the defining attribute of quadratic functions. But once students begin studying quadratics, they may never revisit a symbolic expression without a coefficient of x^2 . On the Quadratic Grapher, watch what happens in the polynomial form of the equation when you vary only the coefficient of x^2 . What does the graph look like when the coefficient of x^2 is 0? A symbolic expression in the form $0x^2 + bx + c$ does not generate the graph of a parabola, but a line – it's a linear function ($bx + c$ is analogous to $mx + b$) (Figure 3)!

Observing the relationship between the graphic and symbolic representations can increase the students' familiarity with the characteristics of quadratic functions and improve their general understanding of functions and the relationships that functions can describe.

In the case of the Parabola Web, feeling comfortable with using the RTT Quadratic Grapher is key to students exploring the characteristics of quadratic functions from multiple perspectives. @

Ronit Carter (rcarter@concord.org) is a member of the Ready to Teach content development team. Fadia Harik (fadia.harik@umb.edu) is a professor of mathematics at the College of Public and Community Service, University of Massachusetts, Boston.

FRIDAY'S LESSON

Using the What-If Builder

Should a tree be cut down in your neighborhood? What if fishermen catch too many fish? What happens if we run out of oil? Each of these scenarios has issues and consequences to consider when making a decision.

A software program developed by The Concord Consortium's Center for a Sustainable Future, in partnership with Cobb

County Public Schools in Georgia, can help students think about these kinds of questions. What-If Builder is a tool for creating scenarios or stories with multiple endings that depend on the choices the reader makes. The program can be used in two distinct ways: to run stories others have made and to create your own.

What-If Builder

What-If Builder is very simple to use. Students pick it up quickly, so little classroom time needs to be spent on mastering the technology.

When running a "What if..." story, students work individually or in groups role playing and debating an issue from different points of view. What-If Builder operates the same way many computer games do: reflecting different perspectives depending on choices the player makes. But unlike a traditional

computer game, What-If Builder encourages students to ask questions, vote, and think deeply about the consequences of their choices.

If students using one scenario don't agree with the consequences built into the story, or feel that other choices should be available, they can easily switch to an editing mode and change the story. Justifying these changes encourages research and investigation of the probable impacts of different choices.

Student thinking is stimulated by using, editing, and creating new scenarios. This can be a strong stimulus to deeper inquiry in almost any field. The point is not to come up with the "right" answer, but to promote visioning and thinking about the future.

Download What-If Builder

What-If Builder software is free and easy to download, and it is compatible with Windows and Mac on all operating systems.

If you are on a PC, point your browser (Internet Explorer works best) to the following URL for downloading instructions:

<http://www.concord.org/esf/resources/software/wib/install.htm>

On a Mac, point your browser (Internet Explorer works best) to the following URL to download:

<ftp://ftp.concord.org/pub/esf/wib/mac/wib.sit>

(When running OS X, launching a What-If Builder story automatically invokes the Classic operating system.)

A successful download should result in a folder that contains documentation, sample stories, and What-If Builder.

Try Out a Story

A good way to get started is to try one of the sample stories, for example, the Fish Story. The scenarios are purposely simple so that the software is not intimidating. (When the What-If Builder opens, two windows appear: the What-If Builder and the Decision Tree.)

To open a story:

- On a Mac, open the WIB folder, and then double-click on a story inside the Sample Stories folder.
- On a Windows computer, launch What-If Builder and select Open from the File menu on the What-If Builder window. Select one of the stories from the Sample Stories folder.

Read the first section of the story, then choose from the selections below it by clicking the "Go ->" button next to your choice. As you make decisions and follow one path of the story, you can also click the "Go Back" button to try a different path. The stories aren't very long, so feel free to explore all of the paths.

If you select Edit Mode from the Tools menu, you can see the complete Decision Tree for the story. Clicking the plus (+) and minus (-) signs allows you to open and close branches of the story.

Create a New Story Using the Decision Tree

A good way to use the What-If Builder in the classroom is to create a story using a three-step story-building process.

Step One: Your Scenario

A Decision Tree helps you set up and see the branches of a story. Think of a story that is relevant to your course and the level of your students. You might want to sketch out a rough Decision Tree for your content before opening the software. Don't get too ambitious. If you give students three

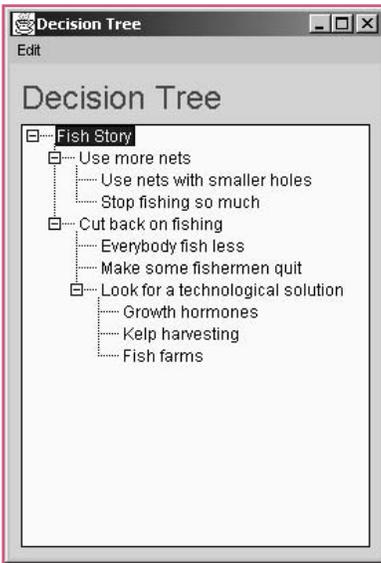


Figure 1. The Decision Tree allows you to see story branching.

Robert Tinker (bob@concord.org) is president of The Concord Consortium.

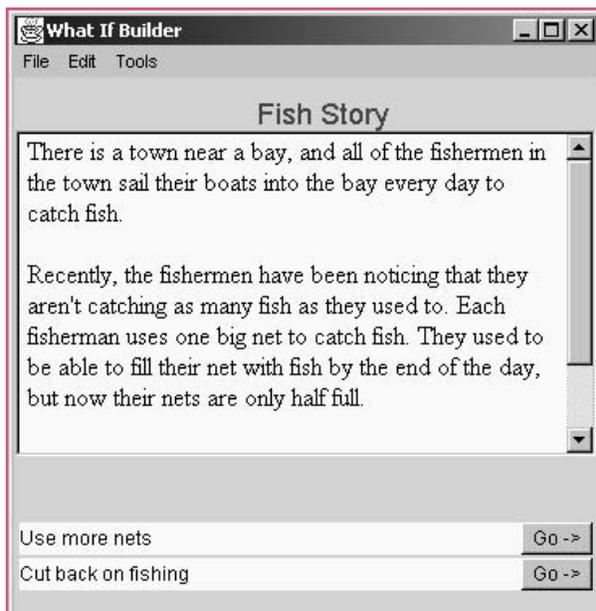


Figure 2. The “Fish Story” starts with a simple scenario. The reader follows one of two possible story lines, thinking about the consequences of each decision.

options three times, you will generate 27 different endings. That is more than enough to get started.

Once you have decided on a Decision Tree and have some idea about the content at each step, launch the What-If Builder.

To create a new scenario:

1. Select New from the File menu.
2. Click New Choice.
3. Fill in the name of your first choice where it says “Title” and click the “Go->” button.
4. Continue using the New Choice and Go buttons to create a nested tree of choices.
5. To go back and add a second level of choices, use the “<-Go Back” button. Look in the Decision Tree window to watch it grow.
6. Use the Decision Tree’s Edit menu to cut, copy, and paste entries.
7. Save your Decision Tree using the Save or Save As command from the File menu.
8. When you are ready to run your Decision Tree, select Run Mode from the Tools menu.

In the Edit Mode, you can view the Decision Tree for the Fish Story scenario (Figure 1). (This scenario is in the Sample Stories folder.) You can see that the first entry, “Use more nets,” gives the user two choices, the first of which is “Use nets with smaller holes.”

Step Two: Editing a Scenario

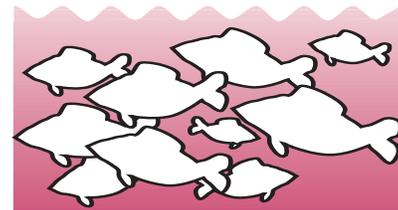
For many students, it may be too much to jump all the way to creating their own scenario, so editing the Fish Story (Figure 2) or one of your scenarios might be a good interme-

diated step. When making your scenario, you might leave some steps blank, or purposely say something that is incorrect. Challenge students to fill in the blank steps or find and correct your error.

A second activity might be to ask students to add several new choices to your scenario, or an entire “limb,” consisting of a new choice that leads to additional choices. You can evaluate students on the thoughtfulness of their additions.

Step Three: Creating a Student Scenario

This is where students create their own scenario. The goal of this activity is to deepen student thinking about a situation, so don’t rush to the computers. Plan ample class time for reflection. If students rename the file, appending their initials, the stories can be saved and sent to you as email for review. (One aid to thinking about situations with feedback can be causal loop diagrams. Intel makes a helpful tool for this available online, called [Seeing Reason](#).)



Every decision has a consequence. Making a Decision Tree using the What-If Builder is a great way for students to experience this firsthand. @

ARTICLE LINKS & NOTES

For a complete Tutorial of how to use the What-If Builder, open the Tutorial file inside the Documentation folder.

[Seeing Reason](http://www97.intel.com/discover/WebTools/SeeingReason/SR_TOC/default.aspx) — http://www97.intel.com/discover/WebTools/SeeingReason/SR_TOC/default.aspx

About What-If Builder

What-If Builder has no built-in point-of-view. It is simply a display and editing tool that can be used in any course at any level. Here are some of the ways it could be used:

Math	Planning how to attack an open-ended problem
Geometry	Finding different paths through a proof
Chemistry	Preparing how to synthesize a compound
Environment	Planning the long-term consequences of various climate policies
History	Deciding whether to go to war
Health	Considering the health consequences of various personal choices
Government	Discovering the interplay of tax policies, growth, and inflation

Inside @concord for Fall 2004

1. Free Computer-Based Learning Resources

Download free open source software for science and mathematics.

2. Perspective: Creating the Educational Golden Gate Bridge

Wide-scale educational innovations require national investment.

6. Monday's Lesson: Handheld Computers in the Field

Handheld computers make educational fieldwork possible anywhere, anytime.

8. Tuesday's Lesson: Making Molecular Models Your Own

Transform Molecular Workbench models with an easy-to-use editor.

10. Wednesday's Lesson: The Starburst Activity

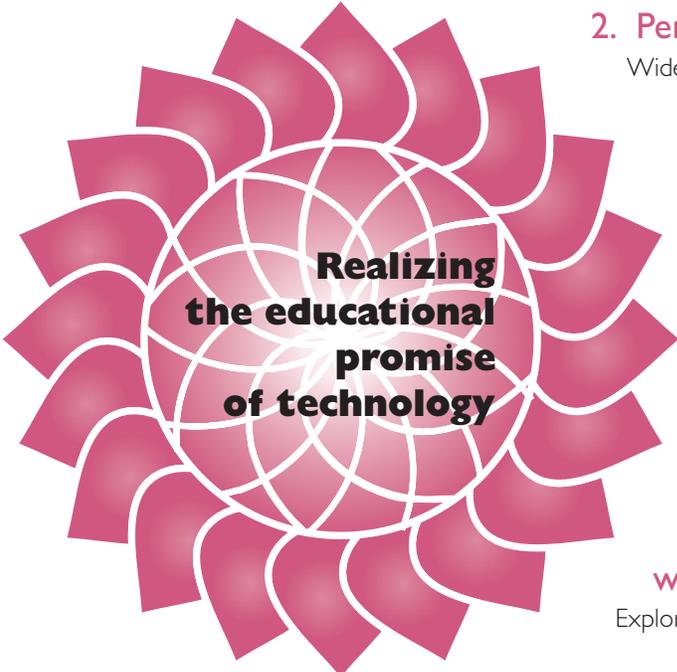
Examine linear functions and their different representations with the RTT Linear Transformer.

12. Thursday's Lesson: Warming Up to Quadratics with the Parabola Web

Explore quadratic functions with the RTT Quadratic Grapher.

14. Friday's Lesson: Using the What-If Builder

Making a Decision Tree using the What-If Builder allows students to see the consequences of their decisions.



**Realizing
the educational
promise
of technology**

Learn From The Experts

This newsletter features five classroom activities from our growing collection of materials based on our free, open source software. For a deeper introduction to these materials, come to one of our workshops planned for January and February 2005. All are led by world-class innovators and feature hands-on learning with the technology.

Probes for science learning. Learn how to use 15 standards-based science activities for grades 3-8. These activities can be delivered online to almost any handheld or full-sized computer using probes from any one of several vendors.

Algebra interactives. Learn how to use our collection of interactive software and associated student activities for topics usually covered in an introductory algebra course. Our online professional development courses featuring these materials will also be demonstrated.

Modeling in science. This workshop covers activities based on interactive models for key topics in biology, chemistry, and physics. The models address concepts from genetics, dynamics, and chemical reactions at the secondary level.

Molecular Workbench. Learn how to use and author models of atomic and molecular interactions that help students understand how the atomic scale determines macroscopic phenomena. Over 200 applications in physics, chemistry, and biology at the middle school, secondary, and college level are available.

Teachers, faculty, curriculum coordinators, and technology coordinators who are interested in implementing our material and in disseminating it to others are invited to attend.

Each half-day workshop costs \$100 and will be offered in our new Concord, Massachusetts, facility. Please see our website for additional information and dates.



10 Concord Crossing, Suite 300
Concord, MA 01742

NONPROFIT
ORGANIZATION
U.S. POSTAGE
PAID
HUDSON, MA 01749
PERMIT #6