Expanding the Science and Technology Learning Experiences of Children

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"Mankind owes to the child the best it has to give." (United Nations Declaration of the Rights of the Child, 1959.)

Origami: See Chapter 2 and Wikipedia.

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About the Author David Moursund

"In a completely rational society, the best of us would be teachers and the rest of us would have to settle for something less, because passing civilization along from one generation to the next ought to be the highest honor and the highest responsibility anyone could have." (Lee Iacocca, American industrialist; 1924-.)

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- Assistant Professor and then Associate Professor, Department of Mathematics and Computing Center (School of Engineering), Michigan State University.
- Associate Professor, Department of Mathematics and Computing Center, University of Oregon.
- Associate and then Full Professor, Department of Computer Science, University of Oregon. Served six years as the first Head of the Computer Science Department.
- Full Professor in the College of Education at the University of Oregon for more than 20 years.
- Started the publication that eventually became Learning and Leading with Technology, the flagship periodical of the International Society for Technology in Education.
- Founded the International Society for Technology in Education. Headed this organization for 19 years.
- Author or co-author of more than 40 commercially-published books and several hundred articles.
- For more information about David Moursund, see http://iaepedia.org/David_Moursund.
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“Children are the message we send to the future.” (Abraham Lincoln; sixteenth US President; 1809–1865.)

“Children are the world's most valuable resource and its best hope for the future” (John Fitzgerald Kennedy; 35th US President; 1917-1963.)

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Preface for Parents and Teachers

"It takes a whole village to raise a child?" (African Proverb.)
"In short, learning is the process by which novices become experts. "
(John T. Bruer. *Schools for Thought*, 1999.)

This book is for parents, grandparents, teachers, and other adult caregivers. Its goal is to help you improve the education of children.

First, how about a little fun to get you started? Try out the free game for adults and children, *Trap the cat*, that is available at [http://www.internetgames247.com/play-6975-Flash_Game.html](http://www.internetgames247.com/play-6975-Flash_Game.html). Try to encircle the cat without letting it get out. You click on a spot where you want a dark circle, and then the cat moves to a circle adjacent to itself. Your goal is to completely surround the cat so it cannot move. The cat’s goal is to get to an outside edge. The reset button in the left corner starts a new game.

![Figure P.1. Screen shot from Trap the Cat game.](image)

Think about what you learn and what a child might learn by playing this simple computer-based game a number of times. Do you see the need to plan ahead? A strategy is a plan of action. Do you eventually develop a winning strategy? Does the game grab and hold your attention?

Suppose that by playing this game with your child, you help your child to learn to focus his or her attention. You help your child to learn to plan ahead. You help your child to deal with sometimes losing, but eventually figuring out how to avoid losing so often. You help your child gain in having persistence and in dealing with situations in which one sometimes loses and sometimes wins.
Wow! These are all lifetime skills! The game by itself helps, but it is you—a responsible and committed adult—who is a prime contributor to the important learning that occurs.

After playing with the game for a while, perhaps you are now ready to get back to tackling this book! In reading this book you will encounter a large number of educational games and other materials that will be interesting to you and that are designed for children.

**Purpose of the Book**

The book is for all adults who are interested in working with children to help improve the science and technology education of children.

A child’s healthy brain has a tremendous capability to learn. It is naturally curious and is always learning—and it learns at an amazing rate. Just try to imagine the amount of learning involved in developing oral fluency in one or more languages. Children do this easily as they grow up in a monolingual or bilingual home and community environment. Imagine the amount of one’s family and local culture that is learned during the first half dozen years of life.

An excellent video on brain science developed by Helen Neville’s research group at the University of Oregon is available free at [http://changingbrains.org/](http://changingbrains.org/).

The adults in a child’s life strongly influence breadth, depth, and quality of informal early childhood learning experiences. From the point of view of a young child every adult (along with siblings, peers, and so on) is a teacher. Every experience is a learning experience.

As you read this book and try out its ideas with children, keep in mind that all people are lifelong learners and lifelong teachers. Every time you interact with a child, you are helping that child to learn, and you are learning about helping children learn.

**More Structured Learning Experiences**

As children progress through early childhood, many parents and other adult caregivers provide some extra depth of learning experiences in areas that they are especially competent in and/or feel are particularly important.

A child growing up in a musical home environment is likely to gain considerably more music knowledge, skill, and interest than a child growing up in an environment that places much less stress on music. The same type of analysis holds for sports environments, academic environments, outdoor nature environments, and so on.
Think about the Science, Technology, Engineering, and Mathematics (STEM) environment available to the children you work with. Important parts of this environment are available in homes, schools, and the general community environment. Parents and teachers can significantly improve the science and technology education of the children they work with by creating home and school environments that emphasize informal STEM education. For example, if you are a parent who lets your children watch a lot of television, think about the very large number of excellent STEM-oriented materials that are now available on television. (See Chapter 7 in this book.) Or, think about what children learn as they build and test fly paper airplanes, do Origami, and engage in a wide range of arts and crafts activities. Computers add an important new dimension to the availability of such materials.

In addition, many parents find it is desirable to make some use of “outside experts” to add to a child’s experiential learning environment. Thus many children take part in music camps, sports camps, art camps, outdoor nature camps, computer camps, and trips to a Science and Technology Museum.

**A Trip to a Science & Technology Center**

A trip to a science and technology center falls between the parent-provided environment and the outside expert-provided environment. Regular trips to such a center can help both you and the children you work with to learn.

Advance planning is highly desirable. Develop some ideas of what you want the children to learn during the tour. The chances are quite good that you can find a Web Page that describes the various parts of the exhibit and briefly discusses some of the underlying science, technology, engineering, and mathematics. If you are serious about children learning through touring an exhibit, try to figure out at least one child-appropriate learning idea for each of the pieces of the exhibit.

This is exceedingly important in terms of child learning. You can approach an exhibit from an adult perspective and your insight into a child’s point of view. If you are touring with your own children, grandchildren, or students you will know a lot about what they know and their views of the world.

Suppose, for example, one of the exhibits is an incline plane that can be used in sliding (flat) blocks or rolling (cylindrical) blocks down the incline plane. The incline plane is inclined at a fixed angle. What do you know about this situation? I’ll bet you know something about sliding friction and rolling friction. Indeed, the invention of the wheel is certainly one of the most important inventions ever made. Notice some of the relevant words and ideas: incline plane, angle of inclination, sliding friction, and rolling friction. Think about what these words mean to you and to young children. Can you think of some things you might do at home or school to
help prepare a child for this learning experience? Can you think of possible roles of lubricants such as water or oil in these incline plane examples?

Next, how about some follow-up? This book contains a large number of activities that you can do with children. Quite a few require some adult supervision. Thus, this book is written for adults, rather than for children, but the focus is on children’s activities. The goal of the book is to help you get better at helping children learn about science, technology, engineering, and mathematics though the use of educationally sound, fun activities.

If you have not already done so, spend a couple of minutes browsing the Table of Contents. You will likely find a number of topics that might interest you and your children. There is no need to read this book from cover to cover. Find a topic that interests you, and go directly to it.

Representing, Thinking About, and Solving Problems

It takes careful thinking to solve challenging problems one has not encountered before. Science, technology, engineering, and mathematics focus on certain types of problems and how to attempt to solve these problems. Over thousands of years, there has been a steady accumulation of know what and know how in the STEM disciplines. Moreover, products of this progress are a routine part of our lives.

This book contains many, varied opportunities to learn more about problems and problem solving. A key idea is transfer of learning from one learning experience to a different application area. Suppose, for example, one learns about paper folding in developing Origami figures. The art of paper folding is applicable to wrapping packages, making decorations to go on packages, making paper airplanes, and in various areas of science. The process of learning to make Origami figures helps to develop patience, skill in following directions, creativity, manual dexterity, and so on.

Finally, adults who work with children in using the Internet need to be especially aware of dangers that lurk there. These child and parent Internet encounters provide an excellent environment for parents to help their children learn about appropriate and inappropriate use of the Internet. An excellent source of information and advice to parents is available at http://www.onguardonline.gov/topics/net-cetera.aspx. Quoting from this Website:

In Net Cetera: Chatting With Kids About Being Online, OnGuard Online gives adults practical tips to help kids navigate the online world.

Kids and parents have many ways of socializing and communicating online, but they come with certain risks. This guide encourages parents to reduce the risks by
talking to kids about how they communicate—online and off—and helping kids engage in conduct they can be proud of. Net Cetera covers what parents need to know, where to go for more information, and issues to raise with kids about living their lives online.

OnGuard Online encourages you to use this guide with your kids, in your school, at your PTA meeting, or anywhere else parents might gather. Feel free to order as many free copies as you’d like, put your own sticker on it, reprint sections in a newsletter or on a website, download a button or link to it, or even reprint it with your own logo. These materials are in the public domain.

In summary, view every activity discussed in this book as a learning opportunity both for you and for the children you work with. As an adult working with children and these activities, figure out what general learning expectations are appropriate to the children you are working with. Then figure out what you can do to enhance the learning experience. Give careful thought to what the children are learning from the experience. Make this learning more concrete by openly discussing it with the children.

Please reread the previous paragraph. Many adults think that if they just place children in a good learning environment (for example, buy them educational toys) the desired learning will sort of magically and automatically happen. They seem to forget the need for explicit emphasis on what is to be learned, and the value of adult-children interaction.

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1. Important Educational Background Information

"The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom." (Isaac Asimov, Russian-born American author and biochemist, 1920–1992.)

This chapter provides a very brief introduction to some of the key ideas in education. Readers who are not professional educators will likely find some of the ideas are new to them. Experienced teachers can use this chapter as a quick review.

Science, Technology, Engineering, and Mathematics (STEM) play a huge role in our everyday lives. Just think about food, clothing, shelter, medicine, transportation, communication, entertainment, and other products and services that contribute to our daily lives. All of these are affected by improvements in technology.

We live at a time of a rapid pace of change in STEM. This pace of change is increasing and is a challenge to people of all ages throughout the world. All children deserve an education that helps them to learn about and to deal with current and likely future STEM changes.

**Informal and Formal Education**

We all know that schooling is important to our children. This schooling is done through public schools, private schools, home schooling, distance education, and so on.

However, formal schooling is only a modest part of a child’s total education. Just think about how much a child learns before starting in a formal kindergarten or first grade. The child has already learned oral communication in one or more languages. The child has made great strides in learning about everyday life in his or her home and community environment. The child has learned to cope with a wide range of routine problem-solving situations.

In addition, the child has learned a great deal about the culture of his or her family and community. The child has learned how to get along with people of all ages, how to make use of a broad range of technological devices, and other aspects of day to day life in the child’s society.

This informal learning environment may also include a substantial amount of semiformal instruction that helps prepare the child for formal schooling. A very
important part of this comes from parents and other adult caregivers exposing children to varied learning experiences—especially reading and interactive communication. On average, children who grow up in an “enriched” environment of such informal education begin school about a year ahead of children who are much less fortunate in their early childhood.

A young child asks a great may “why” and “what” questions. Each provides an opportunity for a two-way conversation. Such two-way communications are quite different than those in which parents and other adults order or tell a child what to do in an authoritative manner. In these two-way communications you can gain insight into the child’s mind and understanding of the world.

Informal education does not stop when children begin school. Even without counting the time a child is asleep, in a year a typical student spends more than three hours outside of school for every hour in school. Thus, a child’s informal education continues to be very important year after year. Parents and other adult caregivers continue to play a major role in the education of their children!

**Some Key Ideas in Education**

Here are some really important educational ideas. If you are a professional teacher, you have probably encountered all of these ideas, and you can easily add to this list. If you are a layperson, some of the ideas are apt to be new to you.

Each learning experience can be analyzed by how well it incorporates these ideas. As you work to help children learn, think about how these ideas fit in with what you are doing. Also think about what you want children to learn about these ideas.

1. **Motivation.** Motivation that comes from within a person is called intrinsic motivation. An intrinsically motivated learner is strongly, personally interested in and involved with what he or she is learning. Research and actual practice indicates this involvement leads to much faster and better learning than when the driving force is extrinsic motivation—motivation that comes from outside the learner. This is a very important idea. Often parents and teachers follow an extrinsic approach to education—rewarding or bribing students for learning and punishing them for not learning. The rewards and punishment issue is beyond the scope of this book. However, research is gradually providing us better approaches.

Remember the quote: “You can lead a horse to water, but you cannot make it drink.” Children are born with innate curiosity and
thirst for knowledge. Our informal and formal education system seems to damage these characteristics in many children.

2. **Feedback.** High quality and immediate feedback, such as occurs in one-on-one or very small group teaching/learning environments, is much more effective than large group instruction. To put this simply, a parent or other adult caregiver working one-on-one with a child greatly speeds up learning and greatly improves retention as contrasted with large group teaching situations.

Self-assessment and formative assessment are two really important ideas in feedback. We want students to learn to judge the quality and correctness of their own work. We want to provide assessment that is not judgmental, but rather is designed to help improve the teaching and learning for individual students.

3. **Learning to Learn.** We are all lifelong learners. But, many of us do not gain an initial education and habits of learning that support a lifetime of independently continuing in our educational endeavors. We do not learn about metacognition and reflective thinking (thinking about our thinking). Many of us fall into patterns of “going with the flow” rather than continuing to actively pursue new knowledge and skills.

4. **Individualization.** Children vary considerably in their learning abilities and interest areas. Through appropriate informal and formal education, learning abilities can be increased and interests can be broadened and deepened. Individualization of content to be learned and instructional processes to meet individual differences of learners contributes substantially to the effectiveness of informal and formal education.

5. **Transfer of learning.** Learning is useful to the extent that one gains the knowledge and skills to make use of the learning in the variety of different situations one will encounter in the future. This is called transfer of learning. Parents can play a significant role in helping their school age children increase the transfer from what they are learning in school to settings outside of school. A simple question, “What did you do in school today?” can instead be changed into a discussion that begins with the request, “Please share with me some of the ways you are currently using or plan to use what you learned in school today.” Be persistent in this
inquiry. A relatively long and deep sharing session of this sort adds greatly to what a child retains from formal schooling.

Many teachers and educational researchers have found the high-road/low-road transfer of learning theory to be quite useful in teaching and learning. In low-road transfer, one learns something to a high level of automaticity. In high-road transfer, one learns a strategy, gives it a name, and practices in on a wide variety of problems. See http://learnweb.harvard.edu/alps/thinking/docs/traencyn.htm. (Note to people who are not school teachers. The chances are that you have not heard of high-road/low-road transfer of learning. Please spend some time learning about this topic. This learning will be of considerable value both to you and to your children.)

6. Islands of expertise. Through informal and formal education, a person develops islands or pockets of expertise. Through practice and more learning, these islands of expertise grow to meet the personal needs of the learner. Thus, for example, a child may develop a personally satisfying level of expertise in doing tricks with a yo-yo, in building and flying paper airplanes, in making origami figures, or in yodeling. The process of developing a personally satisfying island of expertise is an opportunity to learn about one’s personal abilities and interests in learning.

7. Human and computer brains. Human brains get better through informal and formal education, study, and practice. Computer brains get better through building better computers and through the research of thousands of researchers advancing the field of artificial intelligence. If this idea interests you, see Two Brains are Better Than One at http://iae-pedia.org/Two_Brains_Are_Better_Than_One and Five Brains are Better than One http://i-a-e.org/iae-blog/five-brains-are-better-than-one.html. For an introduction to Artificial Intelligence, see http://iae-pedia.org/Artificial_Intelligence.

8. Education for the future. Informal and formal education help prepare children for their future. See http://iae-pedia.org/What_the_Future_is_Bringing_Us. Continued rapid progress in science, technology, engineering, and math is changing our world. It is changing the world our children will face as adults. It is a major challenge to help students get an education that is well
rooted in the cultures and values of the past but that also prepares them for a very rapid pace of change and the types of problems they will face in the future, such as globalization, sustainability, increasingly intelligent and capable computers and robots, nanotechnology, and genome technology.

A key aspect of education for the future is learning to make effective use of the accumulated knowledge of the human race. One way of describing this is that we want each student to develop some of the knowledge and skills of a research librarian. A different way of saying this is we want people to learn to work in teams that include both people and machines—such as computers—to represent and solve problems. Outside of school, “open book, open computer, and open connectivity” are the way people do productive work. You might ask yourself why schools do not place more emphasis on preparing students to work in such environments.

One of the major challenges faced by both adults and children is what constitutes a good education for the future. We live in a time of fast-paced change, particular in things related to science and technology. Historically, the pace of change was relatively slow. An education that was good enough for our parents was good enough for their children.

That is no longer the case. We now have an educational system that tends to be backward looking, while we live in a world that is changing very rapidly. As a parent or teacher, you need to adjust your “educator” thinking into preparing children for the future. A key concept here is less emphasis on rote learning (memorize and regurgitate) and more emphasis on higher-order thinking and problem solving.

Here is a special note for parents. As you talk to your children about what they are learning in school, look for evidence related to the eight ideas listed above. For example, when your child tells you something specific that was covered in school that day, ask probing questions about how this ties in with what was learned in previous days or weeks. Ask question about how it pertains to other topics they are studying, and how it pertains to their lives outside of school. Help you child learn about transfer of learning and learning about learning.

**Science, Technology, Engineering, and Mathematics**

Science, Technology, Engineering, and Mathematics are all deep, broad, and well-established areas of research and development. As you work with children,
you will find it helpful to have some insight into each of these disciplines. The next four subsections give very brief introductions to these four disciplines.

**What is Science?**

Science involves repeatable and accurate measurement, and predictability (see [http://i-a-e.org/newsletters/IAE-Newsletter-2010-56.html](http://i-a-e.org/newsletters/IAE-Newsletter-2010-56.html) and [http://iaepedia.org/What_is_Science%3F](http://iaepedia.org/What_is_Science%3F)). Also see some really nice science-magic videos at [http://www.youtube.com/watch?v=4EABdAEt_fM](http://www.youtube.com/watch?v=4EABdAEt_fM).

You are familiar with a number of different areas of science, such as Astronomy, Biology, Chemistry, and Physics. All of the sciences share much in common. Quoting from the Macquarie Dictionary [www.arc.gov.au/general/glossary.htm](http://www.arc.gov.au/general/glossary.htm):

Science is systematic study of humans and their environment based on the deductions and inferences which can be made, and the general laws which can be formulated, from reproducible observations and measurements of events and parameters within the universe.

Many answers to the “what is science” question include a discussion of scientific method. This is a method of thinking, exploration, and analysis common to all sciences. Quoting from the Wikipedia [http://en.wikipedia.org/wiki/Scientific_method](http://en.wikipedia.org/wiki/Scientific_method):

Scientific method is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. It is based on gathering observable, empirical and measurable evidence subject to specific principles of reasoning. The scientific method consists of the collection of data through observation and experimentation, and the formulation and testing of hypotheses.

Science literacy is a primary goal of science learning for children. Science literacy involves two dimensions. The first is the ability to understand the methods of science, how science influences our daily lives, and to apply science concepts to our understanding of the world around us. The second is the ability—and the inclination—to obtain science information through active investigation, be it indirectly through access to various media information sources, or through direct experience with science phenomena.

It is easy to interact with children in ways that increase their knowledge and understanding of science. Notice the emphasis on understanding. You look up into the sky and see clouds. What is a cloud, where does it come from, why are there more clouds some times than others, what makes clouds move? You see some dark clouds. Why are some clouds dark? You see some jet airplane contrails. Is that where some of the clouds come from? Do the airplane contrails affect our
global environment? You continue to look up into the sky. You see some blue parts of the sky. Why is the sky blue? It is easy to make up challenging questions that relate to understanding various parts of science.

**What is Technology?**

You make routine use of many different kinds of technology. Technology includes the vast collection of processes and knowledge that people use to extend their abilities and satisfy their needs and wants.


> The human race's use of technology began with the conversion of natural resources into simple tools. The prehistorical discovery of the ability to control fire increased the available sources of food and the invention of the wheel helped humans in travelling in and controlling their environment. Recent technological developments, including the printing press, the telephone, and the Internet, have lessened physical barriers to communication and allowed humans to interact on a global scale.

Writing is a technology developed more than 5,000 years ago. Through formal and informal education, people learn to read and write. They are empowered by the expertise they gain in this area, and their lives are enriched.

Each technological development can be examined from the point of view of its positive and negative features and effects. The development of spears, bows, and arrows certainly was advantageous to hunters. However, when used as weapons of war, they have led to the death and injury of a huge number of people.

You are undoubtedly familiar with the current phenomenon of global warming and air pollution, and the contributions our technological developments are making to these worldwide problems. It is nice to travel by car, train, and airplane. It is nice to have a home heated in winter and cooled in summer. All of this technology helps to fulfill our needs and wants—and all contribute to global warming and air pollution.

Since our children are immersed in a technological environment, it is easy to help children learn about capabilities, limitations, advantages, and disadvantages of the various technologies they routinely encounter. Even quite young children can learn about recycling and aid in the recycling process. In addition, you can help them to learn about needs versus wants. We are a society of conspicuous consumption!

**What is Engineering?**

Engineers play a major role in the design and development of the technology we routinely use. Engineering is the application of scientific and mathematical
principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

There are many different kinds of engineers. The U.S. Department of Labor, at its Website http://www.bls.gov/oco/ocos027.htm, lists 17 different types of engineers. Quoting from this site:

> Engineers apply the principles of science and mathematics to develop economical solutions to technical problems. Their work is the link between scientific discoveries and the commercial applications that meet societal and consumer needs.

> Many engineers develop new products. During this process, they consider several factors. For example, in developing an industrial robot, engineers precisely specify the functional requirements; design and test the robot’s components; integrate the components to produce the final design; and evaluate the design’s overall effectiveness, cost, reliability, and safety. This process applies to the development of many different products, such as chemicals, computers, power plants, helicopters, and toys.

Notice the emphasis on use of mathematics, science, and computer technology. Engineering is a demanding and rewarding field of study.

Parents and other people who work with children have many opportunities to help children learn about the field of engineering. As an example, think about details of why one paper airplane flies better and stays aloft longer than another. Think about how the design of a rubber band-powered toy boat affects its performance. Why does water come out of a water facet? Where does the water go when it goes down the drain? How does a toilet work? What makes the light come on when one flips a light switch?

**What is Mathematics?**

Arithmetic is a part of mathematics, but it is a very small part. Math is a language and a discipline of study devoted to representing and solving certain kinds of problems. Math deals with arithmetic problems, geometry problems, algebra problems, calculus problems, probability problems, statistical problems, and so on. See http://iae-pedia.org/What_is_Mathematics%3F and http://iae-pedia.org/Math_Education_Quotations.

In each case, there has been a huge accumulation of knowledge over time. Thus, for example, Isaac Newton and Gottfried Leibniz developed many of the ideas of calculus well over 300 years ago. At that time, these ideas were at the frontiers of math research and helped to advance the field. Now, some students study calculus in high school, and it is a required course for college majors in the various STEM fields.
The following is quoted from a talk that George Polya (1887–1985) gave to a group of elementary school teachers. Polya was one of the leading mathematicians and math educators of the 20th century.

To understand mathematics means to be able to do mathematics. And what does it mean doing mathematics? In the first place it means to be able to solve mathematical problems. For the higher aims about which I am now talking are some general tactics of problems—to have the right attitude for problems and to be able to attack all kinds of problems, not only very simple problems, which can be solved with the skills of the primary school, but more complicated problems of engineering, physics and so on, which will be further developed in the high school. But the foundations should be started in the primary school. And so I think an essential point in the primary school is to introduce the children to the tactics of problem solving. Not to solve this or that kind of problem, not to make just long divisions or some such thing, but to develop a general attitude for the solution of problems. [Bold added for emphasis.]

Mathematics is a very important discipline because there is so much accumulated knowledge about how to solve math problems. If a problem from some other discipline (such as social science, science, or engineering) can be represented as a math problem, then there is a good chance that it can be solved using the accumulated math knowledge of the human race. Computers can be a big help in this problem solving process.

Cognitive Development (Mental)

The brain of a grownup is different than the brain of a child. Educators often mention the research work of Jean Piaget (1896-1980) on stages of brain development (cognitive development). By the time a child starts school, the child may well be quite fluent in one or more natural languages. But, the child does not yet have the logical thinking and analytic skills of an adult. The 6-year-old brain does not understand cause-effect and thinking about consequences of possible actions in the same way as does an 18 or 25-year-old brain. It takes until age 25 or so for a brain to achieve its full maturity.

If child development and brain science are topics that interest you, you can find lots of good resources on the Web. See, for example Brain science and cognitive neuroscience for children and teachers available at http://i-a-e.org/iae-blog/brain-science-and-cognitive-neuroscience-for-children-and-teachers.html.

Here is a brief summary of some of the research results for children at the K-2 grade levels. It is quoted from a federally funded project at the University of California, Berkley http://undsci.berkeley.edu/teaching/k2_nature.php:

The purpose of this segment is to help connect what is known about students' cognitive development with what you want them to understand about science
concepts and the nature of science. Use this brief description, combined with your knowledge of your students, to guide you in making instructional decisions appropriate for your grade level.

Students in grades K, 1, and 2 range in age from 5 to 8 years. During these years, students develop the ability to approach the world logically for the first time. They move from an inability to complete mental operations through even the simplest abstractions to an increasing ability to utilize abstract reasoning. Primary students are naturally curious about their world and learn best through direct discovery in hands-on experiences with manipulatives that engage the five senses.

The primary focus of a kindergartner is to please the teacher. They may struggle to distinguish between fantasy and reality. Some may explain cause and effect through intuition rather than logic.

First grade students are beginning to approach the world logically. They are in a transitional stage between pre-operational thinking and concrete operations. As this shift occurs, students' abilities to reason, understand cause and effect in the natural world, identify differences, compensate for differences, and reverse an idea through mental activity improve.

Second grade students are active thinkers who begin to organize their internal mental structures in new ways. They can now categorize spontaneously for the first time. They have an increasing ability to utilize abstract reasoning, to interpret observations, and to generate expectations about what will occur in a particular situation. Second graders show increasing interest in the world around them—and thus, science takes on a new meaning for them.

The same Website contains similar sections for grades 3-5 students, 6-8 students, 9-12 students, and 13-16 students. See http://undsci.berkeley.edu/teaching/index.php. For additional general information about cognitive development see the Wikipedia article at http://en.wikipedia.org/wiki/Theory_of_cognitive_development.

Final Remarks

The goal of this book is to help foster fun learning interactions between adults and children. Both children and adults will learn through such learning interactions.

Keep in mind that your goal is to help get children ready for their future. This future will be a life in a rapidly changing and challenging world. Be guided by Abraham Lincoln’s statement, “Children are the message we send to the future.”

Also keep in mind the importance of role modeling. You have probably heard the statement, “Monkey see, monkey do.” Role model the curiosity, inquisitiveness, problem solving, and independence of thinking that you want to see in children.
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This is a “one string loosely attached” free distribution. If you find the book useful, you are encouraged (but in no sense required) to make a small tax-deductible contribution to the University of Oregon to show your appreciation. Details are available at the site http://iaepedia.org/David_Moursund_Legacy_Fund.
2. Arts, Crafts, and Constructions

"Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand." (Confucius, 551-479 B.C.)

Many people learn best in a hands-on, learn by doing mode: “Involve me, and I will understand.” The idea is simple enough. How to do something is demonstrated and perhaps talked about by a person with knowledge, skill, and experience. Learners observe, listen, and imitate. The learners provide feedback to themselves, and they receive feedback from the teacher and from their fellow learners. As a result of this type of education, the learner can do things and understand things.

Humans have many tens of thousands of years learning in the “Involve me, and I will understand.” mode of learning. It was just a little over 5,000 years ago when reading and writing were invented. It is only in the past two hundred years that countries throughout the world have begun to focus on all children learning to read and write, and children learning to read well enough so that they can use reading as an aid to learning in various discipline areas.

In a learning by doing environment, both the use of the learning and the feedback occur in a timely fashion—typically, immediately. The learners can see, feel, and sense they are gaining in expertise, and they can demonstrate their increase in expertise. A learner may well be considerable personal satisfaction and an increase in self-esteem through developing or expanding an island of expertise.

Contrast this with much of our formal education system. There, students are often asked to learn things that they will use “sometime” in the future. The “sometime” may be hours, days, weeks, months, or even years in the future. Needless to say, many students have considerable trouble in this type of delayed feedback, delayed use type of learning environment.

This chapter contains information about a number of different “learn by doing” situations that many children (and adults) find fun and interesting. The types of projects described in this chapter are especially valuable when used in an environment involving groups of children with some adult supervision working together. Such environments help children learn to provide feedback to themselves. In addition, children gain skills in figuring out things for themselves, receiving feedback from adults and from each other, and in asking for help when it is needed.

In each of these learn-by-doing situations, children (and adults) gain islands of expertise (small areas of expertise) that may well prove enjoyable and useful for
many years to come. In this process, learners gain increased skill and confidence in learning, and they learn about some of their capabilities and limitations as learners.

**Origami**

![Origami Swan](image)

**Figure 2.1. Swan made from a square piece of paper.**


> Origami (derived from "ori" meaning "to fold", and "kami", meaning paper) is the ancient Japanese art of paper folding. The goal of this art is to create a given result using geometric folds and crease patterns. "Origami" refers to all types of paper folding, even those of non-Asian origin.

See [http://www.ted.com/talks/robert_lang_folds_way_new_origami.html](http://www.ted.com/talks/robert_lang_folds_way_new_origami.html) for a 16 minute video on origami. Quoting from the site: “Robert Lang is a pioneer of the newest kind of origami—using math and engineering principles to fold mind-blowingly intricate designs that are beautiful and, sometimes, very useful.”

There are many excellent origami Websites. For example:

- Using origami to teach math. [http://math.serenevy.net/?page=Origami-TeachingLinks](http://math.serenevy.net/?page=Origami-TeachingLinks)
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Figure 2.2. Origami fish. See http://www.google.com/search?q=origami+fish+dollar+bill&hl=en&rlz=1B5GGGL_enUS316US317&prmd=ivns&source=univ&tbs=vid:1&tbo=u&ei=avEgTcyXCsQOEhODdAg&sa=X&oi=video_result_group&ct=title&resnum=3&ved=0CDMQwQwAg

Paper Airplanes

Figure 2.3. Paper airplane. Picture from http://www.exploratorium.edu/exploring/paper/airplanes.html.

Paper airplanes are fun to make and fly. The builder can receive immediate feedback on the flying abilities of a paper airplane by merely launching it into space. There are lots of commercially available books on building paper airplanes. Here are some excellent Websites:

- How to fold a paper airplane. A good starting place for beginners. http://www.exploratorium.edu/exploring/paper/airplanes.html. (This is the first type of paper airplane that I learned to make as a child. It has brought me great pleasure over the years.)
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- Short videos on how to make many different kinds of paper airplanes. http://www.paperairplanes.co.uk/.

Other Paper Folding Projects

Figure 2.4. Cootie catcher.

A recent Google search of the expression *paper folding* produced about a million hits. The cootie catcher (also called a fortune teller) pictured above is one of my childhood favorites. See http://www.enchantedlearning.com/crafts/origami/fortuneteller/.

The following Websites contains a number of short videos of various paper folding projects.
http://video.google.com/videosearch?hl=en&q=paper+folding&um=1&ie=UTF-8&sa=X&ei=video_result_group&resnum=4&ct=title#.

Paper Snowflakes

Figure 2.5. Paper snowflakes.
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Many children and adults enjoy creating paper snowflakes. All it takes is a piece of paper and a pair of scissors—plus some learning. Trial and error can be a fun part of this learning experience.

There are a large number of websites that provide instructions for making a wide variety of paper snowflakes. The website [http://www.highhopes.com/snowflakes.html](http://www.highhopes.com/snowflakes.html) is a good starting point.

**Virtual Snowflakes**

The Website [http://snowflakes.barkleyus.com/](http://snowflakes.barkleyus.com/) makes it possible for a person to cut out a virtual snowflake, using a virtual pair of scissors and a virtual piece of paper. I found the interface somewhat awkward and it took me some trial and error to get started.

However, it is a fun and educational experience. One of the things a person can learn through use of this free software is some of the differences between “physically real” and “virtual or simulated.” It is now common for architects to develop computerized models (virtual models) of the buildings, bridges, and other structures they are designing. With these models, it is possible to view what the final structure will look like from different angles and viewing elevations. Indeed, with appropriate software, one can do a walk through of a building, walking into each room and viewing the room with different arrangements of furniture and decorations.

**Bridge Building**

![Figure 2.6. Picture from [http://www.abcdpittsburgh.org/kids/kids.htm](http://www.abcdpittsburgh.org/kids/kids.htm)](http://www.abcdpittsburgh.org/kids/kids.htm)

There are many Websites that discuss bridge building projects and contests. These provide excellent examples of highly educational, fun, group and individual projects.

• General Information: Building Bridges from Toothpicks. 

• General Information: Bridges Updated 7/17/07 

• Bridge Design Tips for Kids. This is an excellent resource. 

• Fun and Learning About Bridges. Many good resources. 

• Bridge building competition for high school students. 
  http://www.eng.uc.edu/bridge/. See free book on building bridges out of 
  also contains materials and links that can be used to learn a great deal 
  about designing and building bridges.

Building and Flying Kites

Figure 2.7. Picture from http://www.my-best-kite.com/.

Kite building and kite flying was a fun part of my childhood, and was later 
revisited when I was an adult. My recent Google search of building and flying kites 
produced over 400,000 hits. Here are some good starting places.

• Kite Making Plans. Detailed instructions for making a very large number 
of different kinds of kites. 
  http://www.inquiry.net/OUTDOOR/spring/kites/.
• The Virtual Kite Zoo. This Web page is designed for teachers and others working with a large group of children. http://www.blueskylark.org/zoo/class.html.

• Virtual Kite. The National Aeronautics and Space Administration (NASA) has a Kite Modeler program. Quoting from the site http://www.grc.nasa.gov/WWW/K-12/airplane/kiteprog.html:

With this software you can study the physics and math that describe the flight of a kite. You can choose from several types of kites and change the shape, size, and materials to produce your own design. You can change the values of different variables that affect the design and immediately see the new flight characteristics. With this version of the program, you can even test how your kite would fly on Mars, or off the top of a mountain. The program tells you if your design is stable or not and also computes a prediction of how high your kite will fly.


Construction Projects

Figure 2.8. Picture from http://www.biglearning.org/craft-sticks/.

A recent Google search of craft stick projects produced over 400,000 hits. Craft sticks—frequently called Popsicle sticks—are available free if you eat a lot of such frozen treats, or can be purchased relatively inexpensively in bulk. Here are a few of the Websites I found particularly interesting:

Lego

Figure 2.9. Computerized (virtual) Lego construction software.

Lego blocks have long been a staple in many homes. Children can use their imaginations as they create projects they find personally interesting. Quoting from: http://www.diylife.com/2007/08/10/legos-75th-anniversary-23-diy-lego-ideas/:

There are lots of toys on the market today that can teach children the joy of building stuff, but few are as venerable and versatile as the classic LEGO. For the last 75 years, these colorful connecting blocks have captured the imagination of kids and adults alike, combining to create some truly unique LEGO structures, machines, and useful devises.

… Whether you're wanting to build your own LEGO ultrasonic sonar or rubber band gun, I'm sure you'll find one or two projects on this list that will spark your inner LEGO-addict, compelling you to either drag out the old bucket full of blocks from your closet, or go buy a brand new set from the store.

There are a variety of computerized Lego building block systems available free on the Web. A person can use these systems to construct quite intricate projects.

• http://ldd.lego.com/download/default.aspx takes you to a page where you can download Mac or Windows software. This site allows you do free
constructions. You can also buy the Lego blocks that it would take to build a physical copy of your virtual model.


These three dimensional, virtual, building block systems help users to learn about Computer-Assisted Design (CAD) and gives them practice in three-D visualization and modeling.

**Final Remarks**

Many children learn best in a hands-on, “learn by doing” environment. Working along side their peers, older and younger children, and adults, they learn to make things and do things. They can see the immediate results of their efforts.

Many adults experience great joy in learning alongside children. In the process, they role model the fun and value of being a lifelong learner.

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3. Educational Puzzles

“There are no extra pieces in the universe. Everyone is here because he or she has a place to fill, and every piece must fit itself into the big jigsaw puzzle.” (Lewis Carroll, English mathematician and writer, 1832–1898.)

“Egotism, n: Doing the New York Times crossword puzzle with a pen.” (Author unknown.)

A puzzle is a type of game. A puzzle is a problem or enigma usually designed for entertainment. Often one can solve a puzzle without having to draw upon deep knowledge of any discipline. A jigsaw puzzle and a Rubrics cube provide good examples of this.

A child doing a jigsaw puzzle is engaged in tasks that involve looking for patterns and using spatial visualization skills. This puzzle playing may be done individually or in a small group. In a group setting, there is a strong social education aspect of putting together a jigsaw puzzle.

Contrast a jigsaw puzzle or a Rubric cube with a crossword puzzle from the New York Times newspaper. The crossword puzzle draws upon reading, spelling, word definitions, and word-suggestion clues. It is a substantially different challenge than doing a jigsaw puzzle.

In some cases, there will be a large number of variations on a particular type of puzzle. There are lots of different interlocking jigsaw puzzles, and there are lots of different crossword puzzles. In other cases, a puzzle will be one-of-a kind. Once you have figured out how to solve the puzzle, it is no longer a challenge.

This chapter explores a variety of puzzles and some of their underlying educational values. It provides access to a number of puzzles available free on the Web.

Much of the content of this chapter and the next chapter are drawn from the book Moursund (2008): Introduction to using games in education: A guide for teachers and parents. The book is available free on the Web. It explores various educational uses of games and puzzles. It includes an extensive Appendix of problem-solving strategies that can be taught in a game-playing or puzzle-solving environment.

Free Puzzles Usually Come with a Price

There are huge number and variety of puzzles available on the Web, and many of them are free. However, most often, “free” actually comes with a price. You
have to work your way through a variety of ads and the quality of Websites vary considerably. You may well be offered the opportunity to sign up for a newsletter, or to buy various materials. However, there are indeed some sites that are free, with no gimmicks.

Many people generate and/or accumulate puzzles that they make available free on the Web. Some of the Web-based puzzles can be played on a computer, while others can be printed out and used in a paper and pencil mode. My 1/2/2011 Google search of the quoted term “free puzzle” produced over 500 thousand hits.

**Brainteaser—Think Outside the Box—Puzzle**

One of the important ideas in trying to solve new and challenging problems is thinking outside the box. For a collection of brainteasers see [http://www.begent.org/brainteasers.htm](http://www.begent.org/brainteasers.htm).

This section uses the nine dots puzzle problem to illustrate thinking outside the box.

It is very important to keep in mind that the main goal in having a student try to solve this puzzle is to help the student get better at thinking outside the box. I don’t really care if a student can solve this problem. What I care about is that a student gains increased insight into the idea of thinking outside the box.

Very little is gained by merely memorizing how to solve the puzzle and not giving careful consideration of thinking outside the box and applying this thinking in other problem-solving situations. Such transfer of learning is absolutely essential to getting better at solving challenging, novel problems.

**Problem:** Using pencil and paper, arrange nine distinct dots into a three by three pattern as illustrated in Figure 3.1. The task is to draw four straight line segments with the beginning of the second starting at the end of the first, the beginning of the third starting at the end of the second, and the beginning of the fourth starting at the end of the third, and so that the total sequence of line segments passes through each dot.

![Figure 3.1. Nine dots in a 3x3 square pattern.](image)

See if you can solve this puzzle before reading further down the page.
To begin, you may think about how easy it is to complete the task using five line segments. A solution is given in Figure 3.2. After studying this solution, you can easily find other 5-line line segment solutions.

![Figure 3.2. A 5-line segment solution for the 9-dots puzzle.](image)

How can one possible complete the task with only four line segments? It is necessary to think outside of the box. In this case, the layout of the puzzle tends to create a visual box. Many people do not think about drawing line segments that go outside of the visual box. A solution using four line segments is shown in Figure 3.3.

![Figure 3.3. A 4-line segment solution for the 9-dots puzzle.](image)

I suspect that most parents, teachers, and other adults really don’t care whether students learn how to solve this 9-dots, 4-line segment puzzle problem. However, many people care about helping students learn to think outside the box. Thus, they want students to have an informal and formal educational system that will help students learn to think outside the box.

Thinking outside the box is illustrated by the nine dots puzzle. However, merely having children work to solve this puzzle and then showing them solutions will not help the typical child learn to think outside the box. For most children, it takes many examples and careful teaching over a period of years to develop this type of expertise.

Here is another 9-dot challenge. See if you can use just three connected line segments to draw through all of the dots. As before, think about this before reading further on. Think outside the box!

The chances are that you are like many other people, in that you have studied math for many years, starting in preschool or elementary school. Thus, you can probably explain the difference between a dot and a mathematical point. A dot has size, while a point does not. The puzzle was stated in terms of using nine distinct
dots (not nine points). A 3-line segment solution is illustrated in Figure 3.4. To make the illustration easier to understand, I have enlarged the dots in the puzzle.

![Figure 3.4. A 3-line segment solution for the 9-dots puzzle.](image)

This solution not only illustrates thinking outside the box, it also illustrates the importance of precise vocabulary and the problem solver understanding the meaning of the precise vocabulary.

Here is another puzzle that requires thinking outside the box. This is a “classical” brainteaser puzzle, familiar to many adults.

**Problem:** You are at a river that you want to cross with all of your goods. Your goods consist of a chicken, a bag of grain, and your large dog named Wolf. You have to cross the river in your canoe but can only take one passenger (chicken, dog, bag of grain) with you at a time. You can't leave the chicken alone with the grain, as the chicken will eat the grain. You can't leave your dog Wolf alone with the chicken, as Wolf will eat the chicken. However, you know that Wolf does not eat grain. How do you get everything across the river intact?

This chapter does not contain a solution to the river-crossing puzzle. Remember, the learning value of such a puzzle comes from figuring it out by yourself, by doing metacognition (thinking about your thinking) while you are solving the puzzle, and then by thinking about how what you have learned might transfer to other problems.

If you are unable to solve the river-crossing puzzle problem, you might want to try looking for a solution on the Web. In this task, you face the “how do I look it up” problem. As you work on this problem, do metacognition. When you succeed in solving the information retrieval problem, spend some time reflecting on what you have learned by the process.

Then, spend some time thinking about what you want your children to be learning in terms of thinking outside the box and in learning how to make effective use of the Web as an aid to problem solving. One approach is to share with your children as you carry on such activities. Involve your children in your “shopping trips” on the Web. Involve your children in posing questions and then trying to find answers on the web. Involve your children in facing the challenge of dealing with multiple “hits” when you do a Web search.
Möbius Strip

If you take a strip of paper, glue or tape it into a loop, and then uses scissors to cut along the center of the looped piece of paper, you will get two separate loops. However, if you put a half twist into the strip of paper before gluing or taping, and repeat the cutting process of this loop, you will get only one, longer loop.

![Möbius Strip](image)

Figure 3.5. Möbius Strip.

This is a fun activity for relatively young children as well as for older children and adults. See a video at http://www.youtube.com/watch?v=4bcm-kPluHE. It is a great activity for use in a math class, as it demonstrates a geometric object that has only one side and only one edge. Contrast this with a sheet of paper that has two sides but only one edge., or with a paper chain link that has two sides and two edges.

A Möbius strip is a rather curious mathematical object. When you introduce children to this object, do you help them to explore and experiment with the object, some of the underlying or related math, and the person Möbius? How about art based on the Möbius strip? See http://www.physlink.com/education/askexperts/ae401.cfm.

Toothpick (Matchstick) Puzzles

Here is an example of a toothpick puzzle (also called a match stick puzzle). See AIMS Puzzle Corner: http://www.aimsedu.org/Puzzle/. The goal is to move exactly three of the toothpicks so that there are now five triangles. Hint: Think outside the box!

![Toothpick Puzzles](image)

Figure 3.6. Toothpick “think outside the box” logic puzzle.
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A 10/19/2010 Google search of toothpick OR matchstick puzzle returned about 119,000 hits. As an example, see Matchstick Puzzles at http://www.learning-tree.org.uk/stickpuzzles/stick_puzzles.htm.

In Figure 3.7, you can see two squares outlined by matchsticks. The goal is to move 4 matchsticks to make exactly three squares. You can find two different solutions at the Website mentioned above.

Figure 3.7. Matchstick puzzle.

More Logic Puzzles

The river-crossing example given earlier is a logic puzzle. It requires careful logical thinking to solve the problem. There are many sources of logic puzzles on the Web. My 6/19/2010 Google search on the expression logic puzzle returned about 1.5 million hits.

One of the hits was Logic Puzzles at http://brainden.com/logic-puzzles.htm. It contains a number of puzzles and their solutions. Here is an example of a puzzle from this site:

A square medieval castle on a square island is under siege. All around the castle there is a square moat 10 meters wide. Due to a regrettable miscalculation the raiders have brought footbridges, which are only 9.5 meters long. The invaders cannot abandon their campaign and return empty-handed. How can the assailants resolve their predicament?

Here are some Websites where you can find more logic puzzles.


• Brain Food: http://www.rinkworks.com/brainfood/c/word.shtml. A large assortment of word puzzles.
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- Math Playground. [http://www.mathplayground.com/logicgames.html](http://www.mathplayground.com/logicgames.html). Here is a “classic” letter-substitution example from that site:

<table>
<thead>
<tr>
<th>SEND</th>
<th>Janice Dean is a freshman in the University of North Texas. She has spent all the money for the fall semester. She knows that her father is a puzzle fan. So she mails her father a puzzle as shown at the left.</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ MORE</td>
<td>She knew her father should be able to resolve this puzzle easily and mail the MONEY to her. Each letter stands for a unique digit. Do you know how much money she will be receiving from her father?</td>
</tr>
<tr>
<td>MONEY</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.8. A letter-number substitution puzzle.

- Puzzles and problems: [http://perplexus.info/tree.php](http://perplexus.info/tree.php). This Website uses the following categorization terms for puzzles: logic, probability, shapes, general (includes tricks, word problems, cryptography), numbers, games, paradoxes, riddles, just math, science, and algorithms. Figure 3.9 provides a water temperature puzzle problem from this site.

![Figure 3.9. A water temperature logic puzzle.](image)

There are many similar types of problems available on the Web. They are often called water bucket puzzles. See [http://www.dr-mikes-math-games-for-kids.com/measure-that-volume-puzzle.html](http://www.dr-mikes-math-games-for-kids.com/measure-that-volume-puzzle.html).
Jigsaw Puzzles

Jigsaw puzzles come in many different levels of difficulty. A typical jigsaw puzzle has only one solution, but a person can arrive at the solution in many different ways.

There are quite a variety of different types and difficulties of jigsaw puzzles available free on the Web. Doing such a puzzle on a computer is often quite different than doing a physical (cardboard or wood) jigsaw puzzle. For example, take a look at the puzzle at the top of the page http://www.jigzone.com/puzzles/daily-jigsaw. On 6/8/09 the puzzle of the day was a 67-piece polar bear.

Figure 3.10. Picture of completed 67-piece Polar Bear puzzle.

You can slide pieces around in the display space, but you cannot (and do not need to) rotate the pieces. That is, the pieces are already displayed in their correct rotation.

A 6/19/2010 Google search of the expression free jigsaw puzzle produced over 3.7 million hits. See, for example:

• http://www.crea-soft.com/online-jigsaw-puzzle/ provides a variety of puzzles, with each available in an easy, average, and hard version. The easy versions are quite suitable for preschool-age children.
• http://www.jspuzzles.com/ provides puzzles that do not interlock. Since interlocking is a helpful spatial-visual clue, this increasing the difficulty of the puzzles.

Jigsaw puzzles have a number of educational values. For example, they provide an environment in which one makes use of spatial visualization as well as identifying and making use of color or shape patterns. Jigsaw puzzles illustrate incremental improvement or incremental progress, which is powerful strategies in solving certain kinds of problems. Jigsaw puzzles also illustrate a problem-
solving strategy called divide and conquer. See the next section for a discussion of this strategy.

**Problem Solving Using Incremental Improvement Strategy**
Many types of problems can be solved by incremental improvement. Think about this in terms of walking or running a given distance on a level track. Each step brings you closer to completing the walk or run.

Think about this in terms of completing a jigsaw puzzle. Every piece that is correctly connected to another piece or a group of pieces is a step toward completing the puzzle. It is an incremental improvement.

Lots of “real world” problems can be solved by incremental improvement. On the other hand, many cannot.

Think of this in terms of climbing a mountain. Figure 3.11 shows a cross section of a mountain. Starting at point A, one can make incremental improvement, moving upward at each step (for awhile). Then, however, one reaches the top of a local peak and must go downhill for a while before one can again go up hill.

![Figure 3.11. Incremental improvement (hill climbing) starting from point A.](image)

**Problem Solving by Divide and Conquer Strategy**
Solving crossword puzzles also illustrates another very important strategic approach to problem solving. It is called divide and conquer. Many types of jigsaw puzzles have quite distinct edge pieces. For such a puzzle, it is easy to sort the edge pieces from the non-edge pieces. This divides the original problem into two distinct sub problems.

Often a jigsaw puzzle has some distinctive color or figure patterns, and the pieces for these sub components of the puzzle can be sorted out from the total collection of pieces. This is another use of the divide and conquer strategy.

**Sudoku Puzzles**
Figure 3.12 illustrates the Sudoku puzzle playing board. The coordinate system is used in many different games, including chess and checkers. (Children with a serious interest in chess learn about this coordinate system well before they
encounter it in their math classes.) It helps us to communicate precisely about the location of each of the 81 spaces on the board. Notice that the board is divided into nine 3x3 regions, numbered 1 through 9.

Figure 3.12. Sudoku board grid and nine regions

Figure 3.13 illustrates an actual Sudoku puzzle.

Figure 3.13. An example of a Sudoku puzzle.

A specific puzzle is specified by the set of **givens** entered onto the board, as illustrated in Figure 3.13. The goal (the problem) is to enter a numerical digit from 1 through 9 in each empty space of the 9x9 grid so that:

- Each of the nine regions contains all of the digits 1 through 9.
- Each horizontal row and each vertical column contains all of the digits 1 through 9.

A 6/19/2010 Google search of the expression **free Sudoku puzzles** produced more nearly 13 million hits. For example, see:

- [http://www.websudoku.com/?level=1](http://www.websudoku.com/?level=1)
http://mypuzzle.org/sudoku/ Here you can find 9 x 9 Sudoku puzzles of varying levels of difficulties, as well as 6 x 6 puzzles.

The rules and goal of Sudoku are very simple. Solving the puzzle does not depend on having knowledge of math or any other subject. Indeed, the puzzle might just as well make use of nine different letters from the alphabet or nine different geometric shapes. Sudoku is not a math or a word puzzle. See the 4x4 example in the next sub section.

**A 4x4 Example**

The “standard” Sudoku puzzle is a 9x9 puzzle. However, it is possible to have 4x4 and other sizes.

Just for fun, try solving the two 4x4 Sudoku puzzles given in Figure 3.14. In the numerical version, the goal is to make use of the digits 1, 2, 3, and 4. Each row, column, and each of the four regions is to contain all four of these digits. In the letter version, the goal is to make use of the letters A, B, C, and D. Each row, column, and each of the four regions is to contain each of the four letters.

![Figure 3.14. Two congruent 4x4 Sudoku puzzles, one using digits, one using letters.](image)

The chances are that you will decide that the 4x4 Sudoku puzzle is too simple to be much of a challenge for you. However, it might well be a challenge for young children.

In addition, it illustrates a very important aspect in problem solving. If a particular problem seems too difficult for you, try to create a simpler version of the problem or create a closely related problem that is not as difficult. The process of creating and solving a simpler version or a related problem may well give you insights that will help you to solve the more complex problem.

**KenKen Puzzles**

Figure 3.15 is a 4x4 example. The goal is to fill the digits 1 to 4 into all of the squares, subject to a variety of rules. Examples of rules include that each row and each column must contain all four of the digits, and each of the regions (called cages) surrounded by a heavy black line must contain digits that combine arithmetically to the number in the cage, using the arithmetic operation given immediately after that number.

Thus, in the puzzle given below, notice the cage that includes the upper right corner. The two numbers that go into that cage, when divided, must equal 2. It is easy to figure out that the two numbers must be either 1 and 2 or 2 and 4. However, you need more information to decide whether the two digits are 1 and 2, or 2 and 4. You also need more information to decide where each of these two digits goes.

Notice the cage that contains the digit 3 in its upper left corner, but does not contain an arithmetic operation. This is a “gift—the number that goes in this cage (this square) is a 3. This gives you a “solid” start on solving the puzzle. It still does not help you decide which digits go into the squares that make up the cage that contains either 1 and 2, or 2 and 4.

Consider the cage in the upper left corner. The two numbers in that cage must be 1 and 3. From this you can conclude that the upper left corner contains a 3, and right below it is a 1.

Figure 3.15. A 4x4 KenKen puzzle.
Expanding the Science and Technology Learning Experiences of Children

By now you are probably getting some general ideas of how to attach a KenKen puzzle. Notice the mental arithmetic that is involved. Also notice the value of writing down some of the possibilities for a particular cage or of having a good memory that can be used in place of such writing. With practice, you will improve your mental arithmetic and memory enough so that you can do simple KenKen puzzles without such writing aids—you figure out mentally what number goes into a particular square and write it in.

Quoting from the Website http://www.kenken.com/aboutus_faq.html#K:

• Can a KenKen puzzle always be solved without guesswork?
  Yes, a puzzle can always be solved without random guesswork. However, there are some instances in which small samples of trial and error must be used to eliminate certain solutions. This is found mostly in larger puzzles.

• Do I need math skills to solve a KenKen puzzle?
  Basic arithmetic skills are needed to solve a puzzle. Some puzzles will only use addition, some addition and subtraction, and some will use all four operations. The beauty of KenKen is that you can pick whatever type of puzzle you like!

• Is there only one unique solution to a KenKen puzzle?
  Each KenKen puzzle is created with only one unique solution.

Additional Types of Puzzles
There are many other kinds of puzzles available free on the Web. A few are illustrated in this section.

Puzzles from Puzzle Choice

• Puzzle Choice: http://www.puzzlechoice.com/pc/Puzzle_Choicex.html. See the menu on the left side of the Web page. Quoting from the Website:
  If you like puzzles and games then there are many different types of printable and interactive CROSSWORDS for you to choose from plus a daily US style crossword.
  Check out our WORD SEARCH puzzles or take a look at the WORDPLAY section for anagrams, brainteasers, and other printable word games.
  Test your trivia knowledge with a QUIZ or give your mind a workout with some original LOGIC or NUMBER PUZZLES.
  ONLINE GAMES includes jigsaws, mazes, memory games and a choice selection of classic puzzles and games.
  Kids young and old should visit the KID'S CHOICE section for a variety of fun and educational puzzles and games.
Here is an example of one of the computer-based puzzles in the KID’S CHOICE section (see the menu on the left side of the Website). Begin with a triangle of 11 marbles and one empty space.

![Eleven marbles puzzle](image1)

Figure 3.16. Eleven marbles puzzle.

Remove marbles by jumping over one marble at a time. The goal is to end with as few marbles as possible remaining on the board. The picture below shows the situation after one of the two possible first jumps.

![Eleven marbles puzzle after one “jump.”](image2)

Figure 3.17. Eleven marbles puzzle after one “jump.”

**Math Puzzles from Aims Education Foundation**

AIMS Puzzle Corner: [http://www.aimsedu.org/Puzzle/](http://www.aimsedu.org/Puzzle/). Quoting from this site:

The AIMS Puzzle Corner provides over 100 interesting puzzles that can help students learn to enjoy puzzles and the mathematics behind them. The puzzles are categorized by type, and within each category are listed in order of increasing difficulty. The puzzles have not been assigned a grade level appropriateness because we have discovered that the ability to do a puzzle varies by individual not grade level.

[Editor’s note: Notice that “solutions” is an item at the list of types of puzzles.]

**Liquid-Measuring Puzzles**

Liquid measures logic puzzles are type of math problem that can be solved using a strategy named working backward. Here is an example of a water-measuring puzzle:
Given a 5-liter jug, a 3-liter jug, and an unlimited supply of water, how do you measure out exactly 4 liters?

Think about having arrived at a solution, with 4 liters of water in the 5-liter jug. What are some ways to make 4 liters? Notice that $4 = 5 - 1$; $4 = 3 + 1$; $4 = 2 + 2$; $4 = 1 + 3$.

This simple arithmetic analysis suggest ways to attack the problem. For example, $4 = 5 - 1$ suggests that if you can get exactly 2 liters in the 3-liter jug, then you can fill the 5-liter jug and pour exactly one liter into the 3-liter jug. So, the problem can be solved by getting 2 liters in the 3-liter jug. Can you figure out how to do this?

The computation $4 = 3 + 1$ suggests that you can solve the problem if you can get exactly 1 liter in the 5-liter jug. How can you do that? Well, you might notice that if you fill the 3-liter jug and pour its contents into the 5-liter jug, and then fill the 3-liter jug and use it to add more water to the 5-liter jug, you can end up with 1 liter in the 3-liter jug. Then all you have to do is empty the 5-liter jug and pour 1 liter that is in the 3-liter jug into the 5-liter jug.

You can see that this working backwards type of thinking is used over and over again. Start at something you want to achieve. Back up one step, and this gives you a different goal that you want to achieve. If you can’t figure out how to achieve this goal, try backing up again. This working backwards process can solve lots of problems.

Notice that the same problem can be stated using a different unit of measure.

Given a 5-gallon jug, a 3-gallon jug, and an unlimited supply of water, how do you measure out exactly 4 gallons?

My 6/19/2010 Google search of puzzle problem water measuring produced nearly 3 million hits. There are many different water-measuring problems. According to Ivars Peterson, such problems date back to the 13th century. See http://www.maa.org/mathland/mathtrek_06_02_03.html. Peterson’s article gives additional examples and discusses some of the underlying mathematics of how to solve this type of problem.

Science-based Magic Tricks

You might think of a magic trick as a type of puzzle. This section provides access to a variety of magical tricks that can be explained by their underlying science. See the videos at http://www.youtube.com/watch?v=4EABdAEt_fM.

Arthur C. Clark was a prolific writer of science and science fiction. He is often quoted for his statement that: “Any sufficiently advanced technology is indistinguishable from magic.” To a child, our world is full of magic, and the child
accepts this situation as, “that’s just the way things are.” Imagine an adult from
1,000 years ago encountering a flashlight, airplane, digital camera, or electronic
toys and games.

  Scroll down the page until you come to Science Experiment of the Week. There
you will find a number of “magical” science tricks and explanations of the
underlying science. The explanations are a very important educational part of
these tricks. You want children to learn to “understand” and to dispel the magic
of science.

- Science Tricks. See a number of good videos at
  http://www.youtube.com/watch?v=4EABdAEt_fM.

- Science Tricks. See 10 quirky science tricks at
  http://www.youtube.com/watch?v=i_f3SkxTWxc.

  Contains links to a number of different magic trick resources. Be aware that
many of the sites linked to are commercial.

**Final Remarks**

There are a huge variety of puzzles and they offer a wide variation of types and
levels of challenges. A typical puzzle is both entertaining and mentally
challenging. That is, puzzles can be thought of as “fun” brain exercises that require
active participation.

While some puzzles are “one of a kind,” many can be thought of as general
categories that include a very large number of different examples. Examples of the
latter include crossword puzzles, jigsaw, Sudoku puzzles, KenKen puzzles, and so
on. Both children and adults enjoy such puzzles. Many adults experience great joy
in playing alongside children. In the process, they role model the fun and value of
being a lifelong learner. They may help the children they play alongside with to
become lifelong enjoyers of the puzzles.

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useful, you are encouraged (but in no sense required) to make a small tax-
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Details are available at the site http://iaepedia.org/David_Moursund_Legacy_Fund.
4. Educational Games

All the world’s a game,
And all the men and women active players:
They have their exits and their entrances;
And all people in their time play many parts.
(David Moursund—Adapted from Shakespeare)

When I was a child, I spent many hours playing the game Monopoly. A similar statement holds for my children and for some of my grandchildren. I played because it was fun. However, through this playing I learned a lot about counting, money, strategic planning, informal probability, and about interacting with other children. Clearly, Monopoly and other board and card games that I played as a child contributed substantially to my education.

A game has rules that the players must learn and follow. Typically, a game has one or more players, and often involves interaction among the players. Playing a game well requires planning ahead—thinking about the consequences of one’s moves and actions.

All of these statements apply to the processes of making the decisions and carrying out the day-to-day activities of life in a society of people. Thus, there can be considerable transfer of learning from game playing to the game of life.

Most young children have considerable difficulty learning and understanding the idea that their actions have consequences. Of course, many adults have the same difficulty. The book Moursund (2008) *Becoming more responsible for your education* has an eighth-grade reading level. It is an excellent book for parents to read alongside of their young teen-age children and to discuss with their children.

A computer can take the place of one or more people in a game that requires two or more people. For example, you can play chess, checkers, or Monopoly against a computer. In the process, you will learn about some of the capabilities of game-playing computer programs. A large collection of online games is available at [http://Parade.com/games](http://Parade.com/games).

A networked computer system can also provide assess to other human players who may be located thousands of miles away from you. Some of the massively multiplayer games involve many thousands of participants all playing at the same time.
Will Wright, the video-game designer responsible for the “Sims” titles, says that video games are better at inspiring students to learn than actually teaching them. For a 29-minute talk by Wright, see http://www.bafta.org/awards/video-games/will-wright-video-games-lecture-in-2007,254,BA.html.

There has been a lot of research on use of games in education. The next several sections are designed to help you decide for yourself whether use of games is educationally sound for the children that you work with, and how to make the use of games more educationally sound.

You need to be aware that some games involve much more social interaction than others. Some games are addictive and can lead to antisocial behavior.

**Play is a Child’s Job**

You have probably heard the statement that “play is a child’s job.” There has been a lot of research on how children learn through play. One of the things that we know is that varied, active, and interactive play environments contribute substantially to a young child’s development.

Babies take pleasure in batting at a mobile hanging over a crib, or discovering and playing with their toes and colorful, simple toys. As babies become toddlers and continue to grow, they eventually learn to play with other children. This is a major step forward in a child’s overall social development and it opens new opportunities for play.

Eventually a child’s level of development reaches a stage where the child can participate in a simple card games such as Go Fish (see http://www.pagat.com/quartet/gofish.html) or a board game that involve moving a piece around a board based on numbers produced by a spinner, dice, or drawing a card. These are major intellectual achievements. With appropriate help from older children and/or adults, a child learns that games have rules and games involve taking turns.

Think about how hard it is to learn to skillfully play a card game such as Go Fish. With help, children learn to play far more complex games such as a Monopoly. To play Monopoly and related board games reasonably well requires making decisions such as whether to buy a piece of property and whether to build houses on a piece of property.

Monopoly is sufficiently complex that there are adult-level Monopoly tournaments. There are other games in which there are highly competitive tournaments, such as backgammon, bridge, checkers, chess, cribbage, poker, and solitaire.
Competitive Games

Take a look at the “fill in the names of the states” game at http://www.pibmug.com/files/map_test.swf. It is a solitary-type of one player game. The goal is to click and drag the names of the states onto their correct map locations. The game is timed, so that a slow player runs out of time. Immediate feedback is provided if a name is dragged to the wrong location.

Simple enough. One can use this game to learn the map locations of the 48 contiguous states. With practice, one improves in speed and accuracy. The “competition” in this game is that of playing against oneself. The satisfaction comes from getting better at playing the game, and in eventually becoming quite fast at placing all 48 state names into their correct locations.

Now imaging the same type of setting, but with students competing against each other in timed contests. Who can get the most names onto the map in one minute? Who is the fastest in the class at correctly filling in all of the names?

This simple example illustrated the idea of competition against oneself versus competition against others.

Many games are competitive, involve winning or losing. This immediately raises a difficult question. Some parents want their children to be very competitive, and others don’t. Moreover, there is research to support the contention that girls (on average) like to participate in collaborative games rather than in competitive games, with the opposite being true for boys. Quoting from Tucker-Ladd (2000):

It takes Alfie Kohn [in the book No Contest: The Case Against Competition, 1986] an entire book to summarize the massive data indicating that competition in our society is harmful. Yet, our culture proclaims (without adequate supporting data) just the opposite, that competition is efficient, healthy, and fun. Actually, hard research data documents that people achieve more if they work cooperatively with others (than if they work competitively). We are so brainwashed, we find that hard to believe. (Think of it this way: trying to do your best is very different from trying to beat everyone else.) On the other hand, we can readily accept that a competitive job, school, or social situation, where someone wins by making others fail, causes dreadful stress, resentment of the winner, contempt for the losers, low self-esteem, and major barriers to warm, caring, supportive relationships.

What is the solution? Kohn recommends replacing competition with cooperation, i.e. working together, assuming responsibility for helping each other do our best, and uncritically valuing each other's contributions. [Bold added for emphasis.]

Learning to Plan Ahead

Every day you make a large number of decisions. These vary considerable in importance and long-term consequences. As a child’s brain matures, it gets better at foreseeing the consequences of possible decisions and actions. Most children gradually get better at understanding and accepting the consequences of their actions.

However, this is a long, slow process. Many of one’s decisions and actions are slow to “bear fruit” or to produce significant effects. In contrast to this, many of the games that children play include relatively immediate feedback on the decisions, moves, and other actions a player makes. Thus, games can be a useful aid to children learning to plan ahead and learning that their decisions have consequences.

Most children will not automatically make a transfer of learning from a game-based environment to the non-game environment of their everyday lives. Here, a mentally mature adult, either as a player or as a supervisor of game playing, can contribute mightily to the learning of children.

The science, technology, engineering, and mathematics (STEM) fields of study all have considerable accumulated information, knowledge, and skills. In some sense, this accumulation is somewhat like the rules of a game. However, the rules of these STEM “games” change through research and steady accumulation of knowledge by many thousands of researchers and practitioners.

This type of analysis helps to explain why it takes so many years of study and practice to develop a high level of expertise in the STEM areas. The games of science, technology, engineering, and mathematics are very complex, and they grow more complex year by year.

However, progress in each of the STEM areas also contributes to making it easier for a beginning or novice to participate at a personally satisfying level. In learning STEM, it can be personally satisfying—even exhilarating—to reinvent the wheel. As an example, a relatively young child can easily learn to use a telescope or a microscope. But, the invention of the telescope and the microscope were “big deals” in the history of science. Do you remember the first time you looked in a microscope and found little creatures in pond water?
Somewhat similarly, a child can look at pictures of our moon or earth taken from a space ship orbiting the earth, taken from a space ship orbiting the moon, and taken by both robots and people that have been landed on the moon. Such pictures help a child to gain insights that are way beyond the insights of leading researchers 500 years ago. The earliest known telescope was invented a little over 400 years ago. See [http://en.wikipedia.org/wiki/History_of_the_telescope](http://en.wikipedia.org/wiki/History_of_the_telescope).

**Computer-based Games**

Computers have brought some important new dimensions to the world of play. Here are a few examples:

- A computer can provide quick access to thousands of different games and puzzles—many that are free.
- There are many different battery powered, handheld, easily portable, and quite sophisticated electronic game devices.
- A computer system can manage many of the details of a game and can be a player in the game. If you happen to want to play a game of checkers, chess, or poker, you can find free versions on the Web.
computer system displays the set up board on its screen, serves as an opponent whose skill level you can adjust, and keeps detailed records of all of the moves.

• A computer can facilitate games in which there is simultaneously play by two or more people. Thus, for example, a computer system can help me to find an online opponent in chess, or facilitate my playing in an online bridge game. A computer can facilitate the simultaneous play of many thousands of people in a massively multiplayer online game. See http://en.wikipedia.org/wiki/Massively_multiplayer_online_game.

In addition, computers can be used in interactive, online, edutainment that combiners game-like features with educational features. Probably you are familiar with airplane pilot trainers, spaceship crew trainers, and car driver trainers. These can be thought of as very high quality computer-assisted learning devices or as very high quality realistic games.

For various groups of children and adults, computer games have surpassed television in terms of average hours of play per week. Indeed, it is appropriate to talk about a computer game being addictive and a person being addicted to online games. Quoting from Rideout et al. (2010):

Over the past five years, young people have increased the amount of time they spend consuming media by an hour and seventeen minutes daily, from 6:21 to 7:38—almost the amount of time most adults spend at work each day, except that young people use media seven days a week instead of five.

Moreover, given the amount of time they spend using more than one medium at a time, today’s youth pack a total of 10 hours and 45 minutes worth of media content into those daily 7 1/2 hours—an increase of almost 2 1/4 hours of media exposure per day over the past five years.

Personally, I find this data to be frightening. In a year, average children spend well over twice as many hours (not even counting multitasking) consuming media as they spend in school. Thus, as you work with children, you are faced by the dual challenges:

1. Providing the opportunity for the children to gain the social, educational, and entertainment values of games and puzzles, be they non-computerized or computerized.

2. Helping children learn to deal with the addictive-like and other “bad” characteristics of many games and puzzles.

This chapter includes links to some good sources of information and free online games. However, its main purpose is to help you learn to increase the educational value of the games played by the children you work with.
Learning to Play a Game

As a child, you likely learned to play Tic-Tac-Toe (TTT). TTT is a two-player game, with players taking turns. One player is designated as X and the other as O. A turn consists of marking an unused square of a 3x3 grid with one’s mark (an X or an O). The goal is to get three of one’s mark in a file (vertical, horizontal, or diagonal). Traditionally, X is the first player. A sample game is given below.

Figure 4.3. Example of a Tic-Tac-Toe game.

TTT can be played by a pair of people using pencil and paper. It is also possible to play against a computer. See http://kids.niehs.nih.gov/tictactoe/tictactoe.html. Also see the Kids Pages available at this National Institute of Environmental Health Sciences Website. Spend a minute or so thinking about how a computer is able to play a variety of games. It seems relatively easy to imagine telling a computer how to play TTT quite well. However, what about more complex games? Considerable research in artificial intelligence has been devoted to this endeavor.

When you were first learning to play TTT, you probably played rather poorly, sort of at random. Eventually you learned some strategies that helped you to win more often and/or to avoid losing so often. You may have discovered them on your own, or you may have learned them from better players.

Think about three key ideas from the paragraph given above:

1. Learning to play a competitive game, and experiencing winning, losing, and tying in playing the competitive game.
2. Getting better at playing a game through practice and learning on your own. You might well discover some good strategies on your own, and this is an important success.

3. Getting better at playing a game through instruction from a “teacher” who has more knowledge, skill, and experience. A good teacher can help you to discover some useful strategies, or can directly teach you some strategies.

You can see that these three ideas are applicable in many different game learning and other learning situations. Keep these ideas in mind as you help children learn to play games. You want to help the child learn to apply these ideas in learning of other games and in non-game learning environments. Thus, stress transfer of learning.

Let’s discuss these ideas in a little more detail.

1. Competitiveness. Children vary considerably in their interest in and inclination toward competitiveness. Perhaps you have heard the following two statements:

   • “It’s not whether you win or lose—it’s how you play the game.” (Grantland Rice, sports writer.)
   • “Winning isn’t the only thing—it’s everything.” (Vince Lombardi, football coach.)

   I strongly recommend that you think about it very careful before pushing a child toward either of these extremes.

2. Learning to learn on your own, through experience, metacognition, and reflection, is a very important part of a good informal and formal education. There are many games that can provide a relatively low risk environment in which to practice such learning.

3. A good teacher can help a person make decisions about what to learn and can help speed up the learning process. Thus, for example, suppose you are helping a child to learn to play TTT. You teach the child the strategy: If you get the first move, always play in the center square. You make this recommendation based on your knowledge and experience in playing TTT. But, what is the underlying idea, and does this idea transfer to other game-playing and problem-solving situations? Or, is it just an isolated fact to memorize and then recall when one is playing TTT?
This third point helps us to understand a major flaw in our educational system. It is much easier for a teacher to have a child memorize without understanding than it is to teach for understanding. (For a host of rote memory learning examples, take a look at our elementary school math education system. For a specific example, perhaps you have a recollection of having memorized “invert and multiply” as something having to do with division by a fraction.)

In TTT, a first move into the center square decreases the number of files in which an opponent can make three in a row. Indeed, it decreases the number of such files more than any other opening move. Thus, it is an example of making a move that decreases the number of options or opportunities to win that your opponent has. In chess and in many other games, such strategy is called decreasing your opponent’s mobility or number of good options.

Increasing your mobility and decreasing your opponent’s mobility or number of options are quite useful strategies in many different games and in many non-game competitive situations. It is also applicable in business, politics, war, and so on.

There are many TTT types of games that are far more challenging than TTT. Here are some examples:

- Three dimensional TTT. Use a Web search engine to search for free Mac three dimensional tic tac toe or for free PC three dimensional tic tac toe. You will get lots of hits.

- Gomoku (five in a row). See http://www.5stone.net/en/. The goal is to get five of your stones in a diagonal, vertical, or horizontal row.

![Figure 4.4. Black got five in a row and won this Gomoku game.](image)

- Hex (a connection game). See http://en.wikipedia.org/wiki/Hex_%28board_game%29. Quoting from this website:

  Each player has an allocated color, Red and Blue being conventional. Players take turns placing a stone of their color on a single cell within the overall playing
board. The goal is to form a connected path of your stones linking the opposing sides of the board marked by your colors, before your opponent connects his or her sides in a similar fashion. The first player to complete his or her connection wins the game. The four corner hexagons each belong to two sides.

Figure 4.5. An 11 x 11 Hex board.

- **Connect Four.** See [http://search.teach-technology.com/web_tools/games/connect4/index.html](http://search.teach-technology.com/web_tools/games/connect4/index.html). In Connect Four, columns are formed from the bottom up. For an “n in a row” version, see [http://www.pomakis.com/c4/online/c4.cgi?76450](http://www.pomakis.com/c4/online/c4.cgi?76450). In the example given in Figure 4.6, green won by getting four in a row.

Figure 4.6. The computer, playing green, won this game of Connect Four.

Some Free Educational Games

- **Adventures of Josie True.** See [http://www.tiltfactor.org/?page_id=%20604](http://www.tiltfactor.org/?page_id=%20604). Click on the screens to get the overall story line. Then participate in solving a
mystery. A variety of games are available at this Website. Quoting from the Website:

The Adventures of Josie True is the award winning science and mathematics web adventure game. The design was targeted at middle school girls in order to come at learning software design from a new angle. The project was funded by the National Science Foundation in 1999.

Integral to the research was player testing and research with our target audience, girls age 9-11 years old. We conducted experiments ranging from visual comparisons to interaction research using various game designs with the 5th grade curricular content. We also employed existing research to create better educational software through design.

• Boxerjam. See http://www.boxerjam.com/games/. A large number of free online games with varying educational and entertainment values.

• Fantastic Contraption. See http://fantasticcontraption.com/. An online physics puzzle game with many levels. Requires you to watch an ad before beginning to play.

• Food Force (United Nations World Food Program). See http://www.wfp.org/how-to-help/individuals/food-force. There are several different missions one can undertake. Quoting from the Website:

To underline the game’s main objectives of teaching children about global hunger and WFP’s [Word Food Program’s] efforts to fight it, each mission begins with a briefing on the task ahead by a member of the Food Force team of virtual aid workers.

It is followed by feedback on the player’s performance and an educational video filmed on the frontlines of WFP’s work in the field.

The Food Force site also includes more information about WFP and features a special section for teachers with downloadable lesson plans on what hunger is, why it exists and how to end it. A How to Help section provides ideas on fundraising and school involvement.

• Games, Screensavers, and Children’s Programs: Mohawke's Best of the Best Free and Open Source Software Collection from Dark Artistry. See http://www.digitaldarknet.net/thelist/index.php?page=games. This is a large and varied collection. For example, see the downloadable chess game at http://www.dreamchess.org/downloads.html. (Note that to move a piece, click on the piece and then on the square that you want to move it to.)

• Immune Attack from the Federation of American Scientists, for PC (not Mac). See http://fas.org/immuneattack/. Quoting from the Website:

The Federation of American Scientists (FAS) presents Immune Attack™, an educational video game that introduces basic concepts of human immunology to
high school and entry-level college students. Designed as a supplemental learning tool, Immune Attack aims to excite students about the subject, while also illuminating general principles and detailed concepts of immunology.

- KIDO’Z. See [http://www.kidoz.net/about.html](http://www.kidoz.net/about.html). This site contains a number of graphically oriented interactive games for young children. The games run on both the Mac and Windows operating systems. You must first download a free copy of Adobe AIR. Quoting from the Website:

  **Need We Say It Again? KIDO'Z Is Safe For Kids!**

  Internet safety and security for children is the core concern of KIDO'Z.

  From password-protected Parental Control, to KIDO'Z moderated and pre-approved content, KIDO'Z provides for unparalleled child safety and parental peace-of-mind.

- NIEHS ([National Institute of Environmental Health Sciences](https://www.niehs.nih.gov)) Kids Pages: See [http://kids.niehs.nih.gov/games.htm](http://kids.niehs.nih.gov/games.htm). This site currently contains 37 games for children. They vary considerably in their educational and entertainment values.

- PowerUp from IBM, for Windows (not for Mac). See [http://www.powerupthegame.org/](http://www.powerupthegame.org/). The goal in this game is to save our planet. Quoting from the Website:

  Our atmosphere is choked with carbon dioxide and other greenhouse gases. The planet is heating up. Extreme weather threatens almost every ecosystem and all of our citizens, and storms have destroyed much of the renewable energy infrastructure including wind turbines, hydroelectric generators and solar towers. Fossil fuel plants work overtime to pick up the slack, pumping tons of poison gases into the air, and there are strange, new threats. There have been scattered reports of what people are calling "SmogGobs:" dense clouds of carbon based emissions that seem almost alive. Scientists can not explain the phenomenon - but citizens are blaming these SmogGobs for sickness and even death of loved ones. World leaders have appealed for help, but it may be too late...


  Quoting from the Cambridge Centre for Applied Research in Educational Technology (CARET) site:

  Welcome to the new look of CARET's Brainteasers & Puzzles!

  CARET's projects are selected to promote best practice in e-learning and the application of educational technology. We aim to develop generic tools and systems to support the delivery, assessment and evaluation of pedagogically sound online education, and to establish Cambridge University as a world-leader in this area.
Currently, the site contains 27 highly educational games and puzzles. For a good example, consider Sunny Meadows: http://puzzling.caret.cam.ac.uk/game.php?game=6&age=1. Quoting:

In every ecosystem there is a food chain. In the food chain, species can be consumers (who eat other species), or producers (who are eaten by other species) or both. In this game, there is a simple food chain of foxes, rabbits and plants.

A possible educational use of this simulation would be to have a person play the game or do the puzzle until reaching a certain level of success, and then explain how/why the success is achieved.

- WolfQuest. See http://www.wolfquest.org/. Quoting from the Website:

  Learn about wolf ecology by living the life of a wild wolf in Yellowstone National Park. Play alone or with friends in on-line multiplayer missions, explore the wilderness, hunt elk, and encounter stranger wolves in your quest to find a mate. Ultimately, your success will depend on forming a family pack, raising pups, and ensuring the survival of your pack.

  The WolfQuest experience goes beyond the game with an active online community where you can discuss the game with other players, chat with wolf biologists, and share artwork and stories about wolves.

**Word Games**

There are many word-oriented games that have varying levels of educational value. A 6/20/2010 Google search on the expression *free word games* produced huge number of hits. Many of these can be played online, and some can be downloaded. Here are a few examples.

**Shockwave Word Games**

See http://www.shockwave.com/online/word-games.jsp. The site requires you to sit through an ad before giving access to games. There are 50 free games. I found the game *Prose and Motion* to be particularly intriguing. In *Super Text Twist*, the computer gives you a set of letters. Your goal is to make as many different words from them as possible in two minutes.
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**Boggle and Loggle**


  Quoting from the Website:

  Play the popular word game Boggle™ [free] here.

  In this fast-paced word-search game you have 3 minutes to find as many words (3 letters or more) as you can in a grid of 16 letters. Letters must be adjacent and longer words score better.

  A “hard copy” (physical copy) of the game is widely sold.


  Loggle is a word game based on the popular Boggle™ dice letter game, and was written by Ken Loge using Macromedia Director MX 2004. Loggle is currently available as a Shockwave applet and as a standalone application for the Macintosh and Windows platforms.

  Loggle is designed to be controlled entirely with a mouse to simplify game play. The object of Loggle is to build as many unique words as possible—before you run out of time—by clicking on adjacent letters on the letter grid in the order the letters appear in an actual word. Letters may be connected horizontally, vertically, or diagonally. The longer the word you build the more points it's worth.

**Crossword Puzzles and Puzzle Makers**

My 6/20/2010 Google search on the expression *free crossword puzzles* produced about 18.5 million hits. Numerous sites allow you to select puzzles of varying levels of difficulty, to play online, and to print or download puzzles. There are also a variety of programs that teachers and others can use to create crossword puzzles.

The online crossword puzzles provide a variety of features that you may find appealing. For example, an online site may have the ability to provide hints or to check the accuracy of the words you have entered. Such features may be quite useful as an aid to developing your skills.

- Kentucky Crosswords. See [http://www.kentuckycrosswords.com/](http://www.kentuckycrosswords.com/). This site provides a number of “easy” crossword puzzles as well as more challenging crossword puzzles. It also provides a variety of other types of puzzles.

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**Hangman**

Many children learn to play pencil and paper versions of the 2-person game named Hangman. One player—the Game Master—thinks of a word, indicates the length of the word, and perhaps provides a clue, such as whether the word is a noun or a verb. The other player—the Word Guesser—attempts to guess the letters in the word. Correct guesses are entered into their correct location in Target Word. Incorrect letters are added to the Bad Guess list, and each incorrect letter leads to adding one piece to the gallows picture.


**Scrabble-like Games**

Many commercially developed and widely sold games have been computerized and are available on the Web. While many of these “knock offs” are in violation of copyright laws while some are officially sanctioned.

Here is an example:

Lexulous. See [http://www.lexulous.com/](http://www.lexulous.com/). You must register to play. You can play in various modes, such as against various levels of a computer opponent. The playing board comes up with two options in the middle of the board. Quoting from the Website:

> Welcome to Lexulous, it's the coolest online word game! You can play live against users from all over the world, stay in touch with friends by playing the asynchronous version, or just practice for fun. It's free, and signing up is easy.

**Word Search**

In a word search puzzle, one is given a two dimensional array of letters and a list of words to find within the array. A Google search of the expression *free word search games* returns million hits. One can access a wide of word search puzzles developed by others and one can find software that makes it easy to create a word search puzzle. For example, see [http://www.planetozkids.com/ozzoom/wordgames/index.htm](http://www.planetozkids.com/ozzoom/wordgames/index.htm) and [http://www.funbrain.com/detect/](http://www.funbrain.com/detect/).

**Writing a Story with Your Kids**

This is a fun activity that an adult can do with a child who is just learning to read. The basic idea is for the adult and the child to work together at a computer, writing a story that draws upon the child’s interests and imagination. The resulting
story can be printed out, providing lot of space for the child to draw pictures illustrating events in the story. For more details, see:


A number of teachers use this type of activity at the first or second grade. There, a whole class works together to write a story. The teacher makes use of a computer and display screen so that the students can see the story the being written. The teacher role models editing and other aspects of writing in a computer environment. When the story is competed, it is printed out so that each student gets a copy. The students can practice reading the story, can illustrate the story, and can take the story home and read it to their parents.

**Math Games**

There are many games, puzzles, and instructional materials on the Web that are designed to help children learn math. A Google search of *free online math games* returns millions of hits. See, for example, Helping Your Child Learn Mathematics available in English and Spanish at [http://www.ed.gov/parents/academic/help/math/index.html](http://www.ed.gov/parents/academic/help/math/index.html). Quoting from the site:

This booklet is made up of fun activities that parents can use with children from preschool age through grade 5 to strengthen their math skills and build strong positive attitudes toward math.

Fifteen free games at various grade ranges of students are available at [http://www.crickweb.co.uk/](http://www.crickweb.co.uk/).

A large number of “drill type” games are available at [http://www.sheppardsoftware.com/math.htm](http://www.sheppardsoftware.com/math.htm).

**Tangrams**

Tangram serves as a nice example of a physical and virtual manipulative. This is a Chinese puzzle consisting of a square cut into five triangles, a square, and a rhomboid, to be reassembled into different figures with no overlapping pieces (Tangram, n.d.). Figure 4.8 shows the seven pieces and the pieces arranged into a running person. Tangram is available for free online play at [http://www.apples4theteacher.com/tangrams.html](http://www.apples4theteacher.com/tangrams.html). (Ten examples are shown. Use the Help button for directions.)
Figure 4.8. The seven Tangram pieces made into a running person.

**Tetris**

There are relatively few computer games that women enjoy more than men. Tetris is one of these. It is a solitaire (one-player) electronic game. Tetris (sometimes called Penta is available on a huge range of handheld, game machine, and computer platforms.

![Tetris Pieces](image)

Figure 4.9. The 7 tetrominoes used in Tetris games.


> Seven randomly rendered tetrominoes or tetrads—shapes composed of four blocks each—fall down the playing field. The object of the game is to manipulate these tetrominoes with the aim of creating a horizontal line of blocks without gaps. When such a line is created, it disappears, and the blocks above (if any) fall. As the game progresses, the tetrominoes fall faster, and the game ends when the stack of tetrominoes reaches the top of the playing field.

A Google search using the expression free online Tetris returns a very large number of hits. For example, [http://www.freetetris.org/](http://www.freetetris.org/) provides a variety of versions. Experiment with some of the different versions of Tetris available on the Web until you find one that fits your needs.
Playing this game requires hand-eye coordination, as well as quick recognition of figures in two dimensional space and quick decision-making. I am relatively poor in all of the abilities that it takes to become good at this game. Thus, it is not surprising that I do not enjoy playing Tetris.

However, I find it educational to introspect as I play the game, and I find it interesting to see how practice makes me better at the game. At a beginner’s level, the game can be set so that the pieces fall very slowly and one can experience success. One’s mind/brain/body adjusts (that is, learns) to the demands of the game. I find it interesting to see/sense this learning occurring and to discover that I get better with practice. Through playing this game, I have gained increased appreciation for the learning capabilities of my mind/brain/body.

**Card Games**

There are a very large number of games that can be played with one or more decks of ordinary playing cards. Computer versions of many of these games are available. Yahoo!Kids at [http://kids.yahoo.com/games/games-index?catid=3](http://kids.yahoo.com/games/games-index?catid=3) provides an online version of Go Fish and a number of other card games for children.

Card games provide an excellent environment to practice strategic planning. Card games often involve counting and sequencing, and thus contribute to gaining number sense. And, of course, playing a variety of card games helps to build one’s “card sense” and helps one develop some intuitive understanding for card-based probability.

**Solitaire Card Games**

There are many different solitaire card games. The most commonly played one is called Klondike. For many years, Microsoft has provided a free electronic version of Klondike in its Windows operating system. Thus, it is probably the most widely played electronic game in the world.

Klondike uses a standard 52-card deck of playing cards. The card deck is shuffled and then dealt out, as illustrated Figure 4.10. If you are not familiar with the game, you might want to read a little about its rules at [http://en.wikipedia.org/wiki/Klondike_solitaire](http://en.wikipedia.org/wiki/Klondike_solitaire).
Figure 4.10. The start of a game of Klondike solitaire.

Solitaire card games vary considerably in their intellectual challenges. Some require “deep” thinking as one plans a large sequence of card moves. Others are sort of mindless. The game Eight Off is available along with a number of other solitaire card games at http://www.acecardgames.com/en/. It is one of my favorite solitaire games, and it is quite challenging to play the game well. See Figure 4.11.

Figure 4.11. The start of a game of Eight Off.
Final Remarks

Education has many goals, and there is a huge amount of research and practitioner knowledge about teaching and learning. Games can be used in helping to create a teaching and learning environments that stress:

- Intrinsic motivation—students being engaged because they want to be engaged.
- Learning to learn.
- Learning about one’s strengths and weaknesses as a learner.
- Becoming better at solving challenging problems and accomplishing challenging tasks.
- Transfer of learning from one game-playing environment to another, and from game-laying environments to other environments.

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This is a “one string loosely attached” free distribution. If you find the book useful, you are encouraged (but in no sense required) to make a small tax-deductible contribution to the University of Oregon to show your appreciation. Details are available at the site http://iae-pedia.org/David_Moursund_Legacy_Fund.
5. Virtual Field Trips & Other Aids to Learning

"Learning without thinking is labor lost; thinking without learning is dangerous." (Chinese Proverb.)

"They know enough who know how to learn." (Henry B. Adams; American novelist, journalist, and historian; 1838–1918.)

In the context of computing, virtual means “not concrete or physical.” For instance, a completely virtual university does not have actual buildings but instead holds classes over the Internet. There is a steadily growing collection of free virtual aids to learning available over the Web. This chapter provides some examples.

The Web is a Virtual Library

Your mental picture of a library is probably one of a free, open collection of resources that are easy to browse and to borrow. The picture given below is representative of the chained library that was common until about 1800. Each book is attached to a chain that is long enough to move the book to a reading desk.

![Chained Library, Hereford Cathedral](image)

Figure 5.1. Chained library.

The chains eventually went away, and libraries grew in size. The US Library of Congress is a huge physical library of well over a hundred million items. Nowadays, a search engine such as Google is searching through a virtual library that is at least 20 times as large—and that is only part of what is actually available on the Web.
That is, you can think of the Web as a virtual library containing billions of items. In the “good old days,” physical libraries made use of card catalogs to help people find the physical items that might interest them. Each item in the library was described on one or more cards. The collection of these cards alphabetized and was housed in drawers and was called a card catalog.

Now, physical libraries have switched to using electronic filing systems. In some sense, this is merely a computerization of a card catalogue system. But, the cards in a card catalog don’t contain very much information about the actual physical item.

So, as computers came into use, people got the idea of using a computer to search the entire content of each item in a library. That is akin to what you are doing when you use a search engine to search the Web.
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You may have noticed that search engines are very fast. A search engine is able to do searches so rapidly because much of the search work is done before you key in your search terms. In essence, each search engine creates an index of all of the terms it thinks a user might want to search on. This index is then used to process a user’s search request and quickly find Websites that might be of interest to the user.

**Virtual Manipulatives**

Moyer et al. (2002) defines a virtual manipulative as "an interactive, Web-based visual representation of a dynamic object that presents opportunities for constructing mathematical knowledge" (p. 373).

Many virtual manipulatives are computer simulations of physical manipulatives. This situation provides a good example of the “computational” in sub disciplines such as computational math, computational biology, and computational physics. It also helps to illustrate computational thinking. (See [http://iae-pedia.org/Computational_Thinking](http://iae-pedia.org/Computational_Thinking).) Computational thinking often involves developing computer models (computer models and simulations) as an aid to representing and solving a problem. It involves thinking about use of one’s human brain and a computer brain in problem solving.

**Math Manipulatives**

Quoting from Hartshorn and Boren (1990):

> Experiential education is based on the idea that active involvement enhances students' learning. Applying this idea to mathematics is difficult, in part, because mathematics is so "abstract." One practical route for bringing experience to bear on students' mathematical understanding, however, is the use of manipulatives. Teachers in the primary grades have generally accepted the importance of manipulatives. Moreover, recent studies of students' learning of mathematical concepts and processes have created new interest in the use of manipulatives across all grades.

Math educators often make use of math manipulatives (both concrete and virtual) in helping their students to better understand mathematics. Such hands-on physical and virtual manipulatives are now a common component of elementary school math instruction.
The availability of both physical and virtual manipulative raises an interesting math education question. In terms of student learning, is one type of manipulative more effective than the other? It turns out that a relatively simple research question such as this is really not so simple. What do we mean by "more effective?"

For example, do we look at long-term retention and use of the learning, so that we have to study the students for five or ten years? Do we look at gains in physical manual dexterity and “mousing” dexterity? Do we look at the possible long-term values of learning to move computer representations of physical objects around on a computer screen?

Clements (1999) compares concrete and virtual manipulatives for use in math education and summarizes the research literature. Quoting from his paper:

Students who use manipulatives in their mathematics classes usually outperform those who do not, although the benefits may be slight. This benefit holds across grade level, ability level, and topic, given that use of a manipulative "makes sense" for that topic. Manipulative use also increases scores on retention and problem solving tests. Attitudes toward mathematics are improved when students have instruction with concrete materials provided by teachers knowledgeable about their use.

Quoting The Math Forum @ Drexel (n.d.):

Individual students learn in different ways. When manipulatives are used, the senses are brought into learning: students can touch and move objects to make visual representations of mathematical concepts. Manipulatives can be used to represent both numbers and operations on those numbers. In addition to meeting the needs of students who learn best in this way, manipulatives afford the teacher new ways of visiting a topic.
Virtual Field Trips

There are a very large number of videos available on the Web. Consider a wildlife safari video. Viewing the video is a little bit like being on safari. You might think of it as a virtual safari or a virtual field trip.

A number of science and technology museums have created videos of parts of their exhibits. The article Platoni (2008) *Internet Explorers: Virtual Field Trips Are More Than Just Money Savers* provides useful educational background on this topic.

Additional background information is available in the eSchool News *Gas prices fuel rise in virtual field trips* (http://www.eschoolnews.com/news/top-news/?i=54518). Quoting from this article:

As schools grapple with budget cuts and rising fuel costs, many districts are finding it necessary to reduce or eliminate field trips, leaving students and teachers with a surprisingly attractive option--virtual field trips.

Virtual field trips typically involve students using video conferencing software or using a simple web browser to visit an online destination, such as the web site of a national museum, that offers virtual tours through the facility and up-close, three-dimensional views of geological formations, art work, and so on. They are different from Webquests, which tend to be inquiry-based activities in which students use the internet to answer a set of questions.

Quoting from the Website http://webquest.org/index.php:

A WebQuest is an inquiry-oriented lesson format in which most or all the information that learners work with comes from the web. The model was developed by Bernie Dodge at San Diego State University in February, 1995 with early input from SDSU/Pacific Bell Fellow Tom March, the Educational Technology staff at San Diego Unified School District, and waves of participants each summer at the Teach the Teachers Consortium.

Since those beginning days, tens of thousands of teachers have embraced WebQuests as a way to make good use of the Internet while engaging their students in the kinds of thinking that the 21st century requires. The model has spread around the world, with special enthusiasm in Brazil, Spain, China, Australia and Holland.

Here are a few examples of virtual field trip sites arranged in alphabetical order:

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- Exploratorium Online Exhibits. See [http://www.exploratorium.edu/exhibits/f_exhibits.html](http://www.exploratorium.edu/exhibits/f_exhibits.html)

The Exploratorium is one of the world’s leading science and technology museums. Visit the Exploratorium Homepage at [http://www.exploratorium.edu/](http://www.exploratorium.edu/). There you will find a number of interactive educational materials. For example, test your reaction time in a virtual baseball environment at [http://exploratorium.edu/baseball/](http://exploratorium.edu/baseball/).

- National Zoo. See [http://nationalzoo.si.edu/default.cfm](http://nationalzoo.si.edu/default.cfm). The National Zoo, which belongs to the Smithsonian Institution, offers virtual tours of the zoo, including up-close views of zoo animals via a live webcam.
- Science Museum in the UK. See [http://www.sciencemuseum.org.uk/](http://www.sciencemuseum.org.uk/). Quoting from the Website: “The Science Museum was founded in 1857 with objects shown at the Great Exhibition held in the Crystal Palace. Today the Museum is world renowned for its historic collections, awe-inspiring galleries and inspirational exhibitions.”
- Smithsonian Institution. See [http://2k.si.edu/](http://2k.si.edu/). The Virtual Smithsonian.
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- **Virtual Museum of Science (Virtuality).** The site [http://virtualology.com/virtualsciencecenter.com/](http://virtualology.com/virtualsciencecenter.com/) provides access to a variety of pictures, video, text, and links to related materials.

**Virtual Astronomy**

You know about ground-mounted and orbiting telescopes. This section contains examples of virtual telescopes.

- **Celestia.** See [http://www.shatters.net/celestia/](http://www.shatters.net/celestia/). Quoting from the Website:

  The free space simulation that lets you explore our universe in three dimensions. Celestia runs on Windows, Linux, and Mac OS X.

  Unlike most planetarium software, Celestia doesn't confine you to the surface of the Earth. You can travel throughout the solar system, to any of over 100,000 stars, or even beyond the galaxy.

  All movement in Celestia is seamless; the exponential zoom feature lets you explore space across a huge range of scales, from galaxy clusters down to spacecraft only a few meters across. A 'point-and-goto' interface makes it simple to navigate through the universe to the object you want to visit.

  Celestia is expandable. Celestia comes with a large catalog of stars, galaxies, planets, moons, asteroids, comets, and spacecraft. If that's not enough, you can download dozens of easy to install add-ons with more objects.

- **Google Earth.** See [http://earth.google.com/](http://earth.google.com/). Quoting from the Website:

  Google Earth lets you fly anywhere on Earth to view satellite imagery, maps, terrain, 3D buildings, from galaxies in outer space to the canyons of the ocean. You can explore rich geographical content, save your toured places, and share with others.

- **Microsoft Research WorldWide Telescope (for Windows, not available for the Mac; however, see the second paragraph given below).** See [http://www.worldwidetelescope.org/Home.aspx](http://www.worldwidetelescope.org/Home.aspx). Quoting from the site:

  WorldWide Telescope (WWT) enables your computer to function as a virtual telescope, bringing together imagery from the best ground and space-based telescopes in the world. Experience narrated guided tours from astronomers and educators featuring interesting places in the sky.

  A web-based version of WorldWide Telescope is also available. This version enables seamless, guided explorations of the universe from within a web browser on PC and Intel Mac OS X by using the power of Microsoft Silverlight 3.0.

- **Stellarium.** See [http://www.stellarium.org/](http://www.stellarium.org/). Stellarium runs on Windows, Linux, and Mac OS X. Quoting from the Website:
Stellarium is a free open source planetarium for your computer. It shows a realistic sky in 3D, just like what you see with the naked eye, binoculars or a telescope.

**Virtual Calculators**

There are a huge number of different calculators that are available as virtual calculators (simulated calculators) on the Web. Martindale’s Calculators On-Line Center at [http://www.martindalecenter.com/Calculators.html](http://www.martindalecenter.com/Calculators.html) provides access to over 23,000 of these calculators. Quoting 1/5/2011 from the Website:

Currently the Calculators On-Line Center contains over 23,885 Calculators & Spreadsheets, over 3,865 Courses, Lectures, Manuals, Handbooks, & 1,000's of Movies, Videos, Simulations & Animations

**Virtual Microscope**

You have heard about a variety of types of microscopes. This section provides access to a variety of virtual microscopes.

- **Intel Microscope.** See [http://micro.magnet.fsu.edu/optics/intelplay/simulator/index.html](http://micro.magnet.fsu.edu/optics/intelplay/simulator/index.html). Quoting from the Website:
  
  Welcome to our Java-powered Intel® Play™ QX3™ Computer Microscope simulator. This interactive Java tutorial explores how the hardware (QX3 microscope) and computer software work together to produce digital images. Instructions for operation of this tutorial are outlined below the applet window.

- **Microscopy Pre-lab Activities from University of Delaware.** See [http://www.udel.edu/biology/ketcham/microscope/](http://www.udel.edu/biology/ketcham/microscope/). Includes a 7-minute video introduction to a virtual microscope. Quoting from the Website:
  
  Test your skill. Practice what you have learned. The virtual scope has all the same controls found on the real thing. Microscope controls:
  
  - turn knobs (click and hold on upper or lower portion of knob)
  - throw switches (click and drag)
  - turn dials (click and drag)
  - move levers (click and drag)
  - changes lenses (click and drag on objective housing)
  - select a specimen (click on a slide)
  - adjust oculars (in "through" view, with the light on, click and drag to move oculars closer or further apart)

- **The Virtual Microscope.** See [http://virtual.itg.uiuc.edu/](http://virtual.itg.uiuc.edu/). The site includes a number of educational (training) videos. Quoting from the Website:
The Virtual Microscope is a NASA-funded project that provides simulated scientific instrumentation for students and researchers worldwide as part of NASA's Virtual Laboratory initiative. This site serves as home base for the Imaging Technology Group's contributions to that project—namely virtual microscopes and the multi-dimensional, high-resolution image datasets they view. Currently we provide 90 samples totaling over 62 gigapixels of image data. The Virtual Microscope, which is available for free download supports functionality from electron, light, and scanning probe microscopes, datasets for these instruments, training materials to learn more about microscopy, and other related tools. The project is open source and the code is available on Sourceforge.

- Virtual Electron Microscope. See http://school.discoveryeducation.com/lessonplans/activities/electronmicroscope/. Quoting from the Website:
  Grade level 4–6 students will understand the following:
  1. how microscopes have contributed to our knowledge of life science.
  2. the basic differences between plant and animal cells.

Virtual Manipulatives and Science Activities

Many of us learn best in a “hands-on” environment in which we can do things and then see the results of what we are doing. Thus, for example, in science education it is now common to make use of a wide range of both physical and virtual experiments and explorations.

- Algodoo and Phun. See http://www.phunland.com/wiki/Home. Free graphics and physics-oriented simulation software for the PC and Mac. See the six-minute Phun video at the same site. A couple of minutes into the video you will begin to see interesting examples of simulations models that can be made in this system. Quoting from the Website:
  It may look like a toy, but Phun (and Algodoo) are based on highly competitive technologies for interactive multiphysics simulation, ranging from novel physical models and variational integrators to high performance numerical methods.

- Interactive Simulations. See http://phet.colorado.edu/index.php. This excellent site at the University of Colorado at Bolder contains more than 80 interactive simulations. These vary in level from elementary school to college. For a specific example, see http://phet.colorado.edu/sims/projectile-motion/projectile-motion_en.html. Quoting from the Colorado Website:
  PhET [Physics Education Technology] Interactive Simulations is an ongoing effort to provide an extensive suite of simulations to improve the way that physics, chemistry, biology, earth science and math are taught and learned. The simulations are interactive tools that enable students to make connections between
real life phenomena and the underlying science that explains such phenomena. Our team of scientists, software engineers and science educators use a research-based approach—incorporating findings from prior research and our own testing—to create simulations that support student engagement with and understanding of scientific concepts.

- **Rollercoaster.** See [http://www.funderstanding.com/k12/coaster/](http://www.funderstanding.com/k12/coaster/). Quoting from the Website:

  This simulator is designed for people who want to design their own thrilling coaster and educators who want to use a cool activity to simulate the application of physics by using an exciting interactive tool and access to a wonderful reference source.

  It is your mission to design the coaster so that you can achieve maximum thrills and chills without crashing or flying off the track (unless that's how you like your coaster to work!).


  Try your hand at designing your own roller coaster. You will be building a conceptual coaster using the physics concepts that are used to design real coasters. You won't need to compute any formulas.

  You will decide the following - the height of the first hill, the shape of the first hill, the exit path, the height of the second hill, and the loop.

  When you're done, your coaster will need to pass an inspection for both safety and fun.

**Final Remarks**

As a child, you played with many toys that can be thought of as models of simulations. A toy car has some characteristics of a “real” car. A set of building blocks allows a child to build a three-dimensional object—not too different than what architects do when they build a model of a project that they are designing.

Nowadays, a great many of the tools adults use have built-in computers. Using some of these tools is very much like using a computer simulation or a computerized version of the tools.

Thus, the issue of children students playing with and learning from physical toys, manipulatives, and tools versus playing with and learning from computerized versions of these same objects is not simple. Fortunately, this is not an either-or situation. Children can be immersed in environments that contain both physical and virtual toys and tools. They can gain experience in the merits, ease of use, ease of learning, and so on of both the physical and the virtual.
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6. Digital Photography, Videography, and Graphics

I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks. (Thomas A. Edison; American inventor and businessman; 1847–1931; quotation from 1922.)

"The mind is not a vessel to be filled but a fire to be kindled."
(Plutarch; Roman historian; 46 AD–120 AD.)

Computer technology has greatly changed the fields of photography and videography. It has also made it possible to fully integrate computer graphics and computer animation into photography and videography.

When I was a child, cameras used film that was developed using chemical processes. The film, the developing, and the printmaking were expensive. Movie making didn’t involve making prints, but movie cameras were relative expensive and complex, projectors were expensive, and editing was a complex process.

Now, all of that has changed. Many preschool children use digital cameras. Digital cameras are built into many cell phones. There are “toy” cameras, as well as “toy” microscopes, and binoculars with built-in digital cameras. Instant gratification! Moreover, digital cameras provide instant feedback, which is a great aid to learning.


Videography refers to the process of capturing moving images on electronic media (e.g., videotape, hard disk, or solid state storage, streaming media). The term includes methods of electronic production and post production. It is the equivalent of cinematography, but with images recorded on electronic media instead of film stock.

Digital photography and videography, computer graphics and computer animation, computer storage of images, computer editing of images, computer printing and projecting of images, and other computer-based aids to creating and editing graphics have become routine tools of hundreds of millions of people.

The last section of this chapter provides links to a number of different powerful graphics-oriented software packages. I am amazed at the quality and quantity of graphics software that is being made available free.
Virtual Digital Photography

You might want to play with some of the free educational simulators before continuing with the history and other sections of this chapter. One way to increase your skills in photography is to make use of instructional materials based on virtual photography.

• Camera Simulator. See http://www.kamerasimulator.se/eng/?page_id=2. Quoting from the Website:
  
  With this camera simulator you can try different aperture and shutters to affect a photos light, depth and motion blur. Try also to change the camera’s light sensitivity by manipulating its ISO value. A higher ISO value gives higher sensitivity to light, which allows faster shutter speeds. The disadvantage is that the picture is more grainy.

• Infoborder Online Digital Camera Simulator. See http://www.infoborder.com/News/2009/May/simulator.php. Quoting from the site:
  
  Camera Simulator 1.0 is the first online simulator (19 of May 2009) which presents some important options of a particular camera. User can see the camera during it's work. User can make some pictures from different point of view in different environment. User can try zooming function. It is possible to objects come closer of course as much as the camera's optical lens support. One of the key functions of the digital imaging is the auto focusing systems. User also can see how auto focus systems work, how picture on the display after zooming get sharper.

• SimCam. See http://www.photonhead.com/simcam/. Quoting from the site:
  
  The SimCam is an online camera simulator designed to teach basic photographic principles. Whether you are interested in film or digital photography, the concepts are the same.

  Shutter and Aperture
  Basic f-stop and shutter - Adjust the camera settings and examine the results to understand the relationship between shutter and aperture.

  Film Speed
  Learn about film speed - Shoot the same scene with two different film speeds and compare exposures side by side.

  Camera Shake
  Learn how to spot and avoid camera-shake - Compare wide-angle and zoom examples side by side.
Brief History

The technology of photography and videography has changed immensely since the early days of their beginning successes. Quoting from the History of Photography [http://en.wikipedia.org/wiki/History_of_photography]:

The word photography derives from the Greek words 'photos'—meaning light and 'graphein'—to draw. The word was popularized by Sir John Herschel in 1839. Modern photography began in the 1820s with the first permanent photographs.

Figure 6.1. A photograph taken in 1825.

One way to look at the fields of photography and videography is to study how steady improvements in the underlying technology reduced the technical demands on the user. Quoting from the Wikipedia [http://en.wikipedia.org/wiki/Brownie_%28camera%29]:

Brownie was the name of a long-running and extremely popular series of simple and inexpensive cameras made by Eastman Kodak. The Brownie popularized low-cost photography and introduced the concept of the snapshot. The first Brownie, introduced in February 1900, was a very basic cardboard box camera with a simple meniscus lens that took 2¼-inch square pictures on 117 roll film. With its simple controls and initial price of $1, it was intended to be a camera that anyone could afford and use, leading to the popular slogan, "You push the button, we do the rest."

Motion picture cameras, film, and projectors were developed in approximately the 1880s. Eventually the technology became suitable for use by the general public. Quoting from the Wikipedia [http://en.wikipedia.org/wiki/Movie_camera]:
Movie cameras were available before World War II often using the 9.5 mm film format. The use of movie cameras had an upsurge in popularity in the immediate post-war period giving rise to the creation of home movies. Compared to the pre-war models, these cameras were small, light, fairly sophisticated and affordable. While a basic model might have a single fixed aperture/focus lens, a better version might have three or four lenses of differing apertures and focal lengths on a rotating turret.

You may enjoy a two-minute television broadcast that was made in 1936 and recorded on film as a motion picture. See http://misteridigital.wordpress.com/2007/09/24/the-history-of-video-tape-and-camera/. This illustrates that television existed well before the start of World War II. A major problem was the need for a better medium for recording and editing TV productions.

The development of a video tape recorder (VTR) in the early 1950s made possible the storage of images on magnetic tape. Ampex sold the first VTR for $50,000 in 1956. The first V Cassette R or VCR were sold by Sony in 1971—a combination of a TV set and a VCR cost $1,395. This is somewhat over $7,000 in today’s dollar.

These early video recordings onto magnetic tape were done using an analog (as opposed to a digital) process. However, at the same time, the computer industry was developing digital storage on magnetic tape.

Figure 6.2. Ampex VRX-1000—The first commercial Videotape Recorder.

Figure 6.3. First magnetic tape drive for computer storage.

Quoting from http://www.columbia.edu/acis/history/701-tape.html:
In 1949, IBM began to plan for a new storage and i/o medium to take the place of punched cards. The new medium would be more compact, faster, cheaper, and reusable. Magnetic tape technology had been used for audio recording and playback since World War II, and it was adapted for computer use—initially in a prototype called the Tape Processing Machine (TPM), 1950-51.

Notice the close together dates of the development of digital storage on magnetic tape and the first VTR. Perhaps you have heard the statement, “and the rest is history.” Digital technology has improved at a rapid rate and the cost of computers to process digital information has declined very rapidly. Thus, you can now buy a cell telephone that includes a built-in color digital still and video camera, recorder, and playback device.

**Learning to Use the Digital Photography and Videography Tools**

The low cost of digital still and video cameras, storage devices, and editing facilities mean that even young children can learn to use these tools.

You realize, of course, that there is a huge amount of learning required to become a “professional level” photographer or videographer. A person can learn through trial and error, through making use of instructional materials available in books, magazines, and on the Web, through taking courses, and so on. There is a substantial amount of free instructional material available on the Web. (Google: *free lessons digital photography.*) Here are some examples of these instructional materials.

- **Adobe Digital School Collection Teacher Resources.** See [http://www.adobe.com/education/instruction/adsc/](http://www.adobe.com/education/instruction/adsc/). Quoting from the Website:

  > Technology integration is a key mechanism for augmenting classroom instruction while helping students learn lifelong communication skills for the digital age. Use these lesson plans—which incorporate technology education through the use of Adobe® Digital School Collection software—when teaching about math and science, language arts, history/social studies, and visual and performing arts.

- **Digital Photography Tutorials.** See [http://www.cambridgeincolour.com/tutorials.htm](http://www.cambridgeincolour.com/tutorials.htm). Quoting from the Website:

  > Learn how to take and edit digital photographs using visual tutorials that emphasize concept over procedure, independent of specific digital camera or lens. Topics range from basic camera tips to advanced techniques.

- **Geoff Lawrence.com.** Quoting from [http://www.geofflawrence.com/](http://www.geofflawrence.com/)

  > This free digital photography tutorial site is designed to show you how to take better photographs. With a little knowledge and thought before taking a photo, you can turn a 'snap' into a picture that will delight your viewers rather than bore the pants off them.
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• **Photography Course.** Quoting from [http://photographycourse.net/](http://photographycourse.net/)
  
  This Free Photography Course offers free photography lessons ranging from the basics of film, optics, cameras and light to web page layout and digital photography. FIRST, a Basic Primer, an introductory textbook lesson covering film, optics, and flash for those who have never studied the art and science of photography. Back To Basics . You MUST have this solid foundation, it won’t take that long! You don’t need to memorize all of this information, but it is essential that you are aware of these important fundamentals.

  
  The site provides free access to a number of instructional materials. Also, you may enjoy experimenting with one of the animations in a lesson on Understanding Exposure at [http://www.photocourse.com/itext/exposure/](http://www.photocourse.com/itext/exposure/). You can play with a picture, changing the amount of exposure.

• **Videomaker.** See [http://www.videomaker.com/learn/](http://www.videomaker.com/learn/). Quoting from the Website:
  
  Learn Videography, video editing, and lighting. A large part of our mission is to provide you with the information you need to improve your skills in video production. And after 20 years of publishing, we have a lot to offer. This is the place to start for videography training. Here you will find hundreds of articles about audio/video software, video editing hardware, and help with video lighting techniques. Let the learning begin!

**Creating Computer Graphics**

There are a lot of good quality graphics software packages available free on the Web. Here are a few examples:

• **Art Pad.** See [http://artpad.art.com/artpad/painter/](http://artpad.art.com/artpad/painter/). Provides a pallet of colors and a small paint brush for doing the types of drawing and scribbling that one often sees done by children just learning how to use coloring crayons and color pencils. It has additional features that will interest somewhat older children. (Note that when I used this software on 1/7/2011 it came up slowly and with some error messages at the top of its home page. However, the software seemed to work correctly.)

• **Art Rage.** See [http://www.artrage.com/artragedown.html](http://www.artrage.com/artragedown.html) for a free Starter Edition for Mac and Windows. Quoting from the Website:
  
  Artrage is a great little program that enables you and the students to make your own virtual artwork. There is a 'cut down' version of the program that you can use for free which is very good.

• **Beautiful Dorena.** See [http://www.dryreading.com/dorena/index.html](http://www.dryreading.com/dorena/index.html). Macintosh only. This free software was developed by Craig Hickman who
developed Kid Pix much earlier in his career. Kid Pix is now a commercial product that is available both for Mac and Windows and is widely used in elementary schools as well in children’s homes. A home edition is (inexpensively) commercially available at http://www.k12software.com/view_details.php?PHPSESSID=bbc324dc0b86e63160142d09da2c7dac&ID=2744.

• Blender. See http://iae-pedia.org/Blender. Quoting from the Website:
  Blender is a free open source 3D content creation suite, available for all major operating systems. With Blender you can:
  1. Make 3D models.
  2. Produce animations.
  3. Create physics simulations.
  4. Develop interactive 3D content and games.
  5. Edit video and image sequences (slideshows).

  Provides brief description and links to a lot of free graphics software.

• Kaleidosketch. See http://www.pumpkinpirate.info/ks/. Kaleidosketch is a kaleidoscope-inspired symmetry drawing program. The idea is pretty simple. You draw in the canvas, and Kaleidosketch creates symmetry by rotating and reflecting your drawing in real time. You have control over virtually every aspect of the process. You can change the number of rotations, whether your drawing is reflected, the center of rotation, the line width, color, and how that color changes as you draw.

• Open Source Software Packages. See http://iae-pedia.org/Open_Source_Software_Packages
  This site includes brief descriptions and links for 10 different graphics packages.

• Paint.net. Windows only. See http://www.getpaint.net/download.html#download.
  Paint.Net is a free piece of image and photo manipulation software.
  Features: unlimited undo, special effects filters, cropping, paint fill, brightness and contrast, layers, color correction and many others. NB This photo editing software has many of the same features as Paintshop Pro and Photoshop but it is free.
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• Picasa for Mac and Windows. See http://picasa.google.com/mac/. This takes you to the Mac download site. See the right end of the menu at the bottom of the page for a PC download. Quoting from the Website:

  Picasa is free photo editing software from Google that makes your pictures look great. Sharing your best photos with friends and family is as easy as pressing a button!

• Rainbox for the Macintosh. Quoting from the Website http://graphicssoft.about.com/library/daily/bldd062800.htm:

  Rainbox is a free psychedelic painting program that is fast and very easy to use. Uses palette animation to make your drawings appear to be moving. The software is simple enough that children or anyone can create colorful, hypnotic, and dazzling artwork, with no computer experience. Rainbox also includes a screensaver module that will let you use your Rainbox pictures as screen savers.

• SketchUp (Google SketchUp). See http://sketchup.google.com/. Quoting from the Website:

  Welcome to Google SketchUp. You can use Google SketchUp to create, modify and share 3D models.

• Stykz. See http://www.stykz.net/Home.html. Stykz is a free multi-platform stick figure animation program. Quoting from the Website:

  Stykz is frame-based, letting you to work on individual frames of your animation; onionskinning lets you to see what was in the previous frame so you can make adjustments accordingly.

  Figures can be rotated, scaled, flipped, duplicated, colorized, and relayered. Select multiple figures by shift-clicking or creating a selection rectangle and align them using the alignment options in the Property palette.

• Sumo Paint. See http://www.sumopaint.com/app/. Runs online via your browser.

  A free comprehensive pixel-level “paint” program.


  The Color Wizard teaches children how to use light, shadows, reflections, texture, perspective, and color, to create their own masterpiece. It is much more than an ordinary coloring book! Paint with over 700 different colors. Apply highlights and shadows. Press the Artist Icon for art lessons, or the Book Icon to read the story behind the picture you are coloring.
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- The Free Mac Classroom. See http://web.mac.com/simon_elliott/simon_elliott@mac.com/Graphics.html. Contains a large number of links to Utilities, CAD and Animation, and Graphic Tools & Viewers. Some are multi platform.

- The Gimp. For Windows. See http://gimp-win.sourceforge.net/. This software has many of the same features of packages like Photoshop and Ulead, but it is free.

- Tux Paint. See http://tuxpaint.org/download/. Tux Paint is a free, award-winning drawing program for children ages 3 to 12 (for example, preschool and K-6). It combines an easy-to-use interface, fun sound effects, and an encouraging cartoon mascot who guides children as they use the program. Kids are presented with a blank canvas and a variety of drawing tools to help them be creative.

Final Remarks

Digital photography, digital video, and computer graphics provide an excellent example of powerful uses of Information and Communication Technology in informal and formal education. Children and adults of all ages can learn to use these tools.

There is a wide range of free computer tools in this area. They range from tools for the very young novice to professional level tools for experts. These tools have greatly changed the worlds of photography, filmmaking, animation, and commercial art.

Such tools empower children. They allow relatively young children to do things that used to cost a lot of money and could only be done by adults. The idea of using computers to empower students is a very important aspect of changes that can be made in education via appropriate access to and use of computers. See http://iae-pedia.org/Empowering_Learners_and_Teachers.

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7. Educational Videos

Books will soon be obsolete in the schools. ... Scholars will soon be able to instruct through the eye. It is possible to touch every branch of human knowledge with the motion picture. (Thomas A. Edison; American inventor and businessman; 1847–1931; quotation from 1913.)

"The most dangerous experiment we can conduct with our children is to keep schooling the same at a time when every other aspect of our society is dramatically changing." (Chris Dede, written statement to the PCAST panel, 1997.)

There is a huge and steadily growing collection of videos available on the Web. They vary tremendously in quality and in educational value. This chapter provides links to some free educationally oriented videos and video collections.

A Huge Collection of Free Educational Videos

See http://www.watchknow.org/Default.aspx. This is a 22,000 item collection of educational videos for children ages 3 to 18. As of 12/17/2010 the list included Computers and Technology (828 videos), Mathematics (2,816 videos), Science (4,522 videos), and Hobbies and Crafts (365 videos).

Note that you may find that these videos are slow to load. The videos vary tremendously in educational quality and value. For example, suppose you want to learn a little bit about drawing female and male faces. Then two good examples are available at http://www.watchknow.org/Video.aspx?VideoID=14460 and http://www.watchknow.org/Video.aspx?VideoID=14459.

STEM Videos


This 9:49 video presents the work of Mr. Bolinsky's group's work on doing scientific images and animation. It includes a 3 minutes of a longer video showing the vast and complex inner workings of a cell responding to a special situation.

See also Biovisions at Harvard, available at http://multimedia.mcb.harvard.edu/. See the menu on the left side of the screen.

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A number of free biology videos are available from The National Academics Press. Use the link given below to access a free online copy of the 2009 book, A
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New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution and a short video about the book. The page containing the video provides links to a number of biology and other science videos.


- Brain Science.
  - Information Age Education: http://iae-pedia.org/No_Cost_Educational_Videos#Brain_Science.


As an example: The Computer History Museum in Mountain View, California provides a considerable and growing collection of videos. An outstanding example is a 5:47 video titled Charles Babbage and his Difference Engine #3, available at http://www.youtube.com/watch?v=KBuJqUfO4-w&feature=channel_page.

Here is another example: Computer Science for Children (50 minutes). http://www.youtube.com/watch?v=j28hg8XHugU&NR=1. This is a live presentation before an audience of middle school students.

Here is a third example: Nicholas Negroponte: One laptop per child. http://www.ted.com/index.php/talks/nicholas_negroponte_on_one_laptop_per_child_two_years_on.html. A pioneer in the field of computer-aided design, Negroponte initially gained great success in founding and directing MIT's Media Lab, which helped drive the multimedia revolution and now houses more than 500 researchers and staff. Learn more about Negroponte at http://iae-pedia.org/Nicholas_Negroponte.

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- Science and Technology. See http://iae-pedia.org/No_Cost_Educational_Videos#Science_and_Technology.
- Soap and Other Bubbles. See http://iae-pedia.org/No_Cost_Educational_Videos#Soap_and_Other_Bubbles.
- Teachers’ Domain. See http://www.teachersdomain.org/about.html. Quoting from the Website:

  Teachers’ Domain is an online library of more than 1,000 free media resources from the best in public television. These classroom resources, featuring media from NOVA, Frontline, Design Squad, American Experience, and other public broadcasting and content partners are easy to use and correlate to state and national standards.

  Teachers’ Domain resources include video and audio segments, Flash interactives, images, documents, lesson plans for teachers, and student-oriented activities. Once you register, you can personalize the site using “My Folders” and “My Groups” to save your favorite resources into a folder and share them with your colleagues or students.

  Teachers’ Domain strives to strengthen teacher knowledge by providing innovative teaching methods that incorporate technology in the classroom and inspire students to learn.


Technology, Entertainment, Design Videos

Quoting from the Website http://www.ted.com/pages/view/id/5:

TED is a small nonprofit devoted to Ideas Worth Spreading. It started out (in 1984) as a conference bringing together people from three worlds: Technology, Entertainment, Design. Since then its scope has become ever broader. Along with the annual TED Conference in Long Beach, California, and the TEDGlobal conference in Oxford UK, TED includes the award-winning TEDTalks video site, the Open Translation Program, the new TEDx community program, this year's TEDIndia Conference and the annual TED Prize.

As of 1/8/2011 Website http://www.ted.com/talks lists over 850 educational and entertaining videos. Most are about 19 minutes in length, but some are quite a bit shorter. All feature people telling their stories to the attendees at the annual TED Global Conference. These presentations are of high quality and probably most suitable for high school students and adults.

A number of education-oriented TED videos are listed and briefly described at http://iae-pedia.org/TED_Talks. Here are some that I found to be particularly interesting:
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  Venice, Italy is sinking. To save it, Rachel Armstrong says we need to outgrow architecture made of inert materials and, well, make architecture that grows itself. She proposes a not-quite-alive material that does its own repairs and sequesters carbon, too.


  The dot-com boom and bust is often compared to the Gold Rush. But Amazon.com founder Jeff Bezos says it’s more like the early days of the electric industry.

  About Jeff Bezos. As founder and CEO of Amazon.com, Jeff Bezos defined online shopping and rewrote the rules of commerce, ushering in a new era in business. Time magazine named him Man of the Year in 1999.


  Susan Blackmore studies memes: ideas that replicate themselves from brain to brain like a virus. She makes a bold new argument: Humanity has spawned a new kind of meme, the teme, which spreads itself via technology.


  Paul Debevec's digital inventions have powered the breathtaking visual effects in films like The Matrix, Superman Returns, King Kong and The Curious Case of Benjamin Button.


  As globalization and technological advances bring us hurtling towards a new integrated future, Ian Goldin warns that not all people may benefit equally. But, he says, if we can recognize this danger, we might yet realize the possibility of improved life for everyone.
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  Henry Markram says the mysteries of the mind can be solved—soon. Mental illness, memory, perception: they’re made of neurons and electric signals, and he plans to find them with a supercomputer that models all the brain’s 100,000,000,000,000 synapses.

  
  Sir Ken Robinson makes an entertaining and profoundly moving case for creating an education system that nurtures (rather than undermines) creativity.

  
  Mr. Rosling has spent a lot of time in Africa, and he has a lot of objections to the idea of "developed and undeveloped world", instead just saying folks are just at different stages because they've started at different places. He makes an interesting point that Africa has moved incredibly rapidly from a very "pre medieval" level of development to where maybe Europe was in the early part of the 20th century in 50 years.

  This talk presents a modern, computer-based way of viewing complex statistical data. The representations are far removed from the traditional graphs that most people use.

  
  Alan Russell studies regenerative medicine–a breakthrough way of thinking about disease and injury, using a process that can signal the body to rebuild itself. The video shows some of the latest developments in regenerative medicine, and presents a vision of a future that is much different than today’s medicine.

  One of the education ideas that Russell mentions is the need for interdisciplinary education and the need for teams of people from different disciplines to learn to work together on difficult problems. This is an important aspect of an Information Age education.

Miscellaneous Topics

- Diet Coke and Mentos Candy. See the geyser experiment (Retrieved 1/8/2011) at
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• First Tech Support Guy. See (Retrieved 1/8/2011) http://www.youtube.com/watch?v=9J9-Qr7oz-4. This is a 2:37 video in Norwegian, with English subtitles. It is a parody on technology support, based on the tech support needed to deal with a book.

• Humorous five-minute video of Father Guido Sarducci. (Retrieved 1/8/2011). http://www.youtube.com/watch?v=kO8x8eoU3L4. The first part of the transcript is given below.

I find that education, it don’t matter where you go to school, Italy, America, Brazil, all are the same—it’s all this memorization and it don’t matter how long you can remember anything just so you can parrot it back for the tests. I got this idea for a school I would like to start, something called the Five Minute University. The idea is that in five minutes you learn what the average college graduate remembers five years after he or she is out of school. It would cost like twenty dollars. That might seem like a lot of money, twenty dollars just for five minutes, but that’s for like tuition, cap and gown rental, graduation picture, snacks, everything.


• Metamorphosis of a Cube. See (Retrieved 1/8/2011) http://erikdemaine.org/metamorphosis/SoCG99_final/Apr13_halfsize_cmp.mpg (This loads a great deal faster if you copy and paste the address into a browser.)


  See hundreds of free, high quality educational and entertaining videos.


• Steve Spangler Science. See http://www.stevespanglerscience.com/who-is-steve-spangler.html for information about Steve Spangler. On the right side of the page is a list, "Top 10 Experiments." Each is accompanied by one or more short videos.
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Final Remarks

The 1913 forecast by Thomas Edison given at the beginning of this chapter has not yet come to pass. However, the Web is a valuable and growing warehouse of educational videos. These are playing a steadily increasing role in informal and formal education.

The next chapter discussed distance education.

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8. Distance Education

“The medium is the message.” (Marshall McLuhan; Canadian educator, philosopher, scholar, and communication theorist; 1911–1980.)

"An educated mind is, as it were, is composed of all the minds of preceding ages." (Bernard Le Bovier Fontenelle; mathematical historian; 1657-1757.)

Distance education—often referred to as distance learning or online education— is now a relatively routine component of informal and formal education systems in the United States and in other parts of the world. Opportunities exist to get K-12 education, community college education, technical school education, bachelor’s degrees, master’s degrees and doctorates through distance learning. An increasing number of students of all ages are taking advantage of these opportunities.

In addition, a great many courses are available free to those who do not need credit and the help from online instructors.

Nowadays, whenever you engage in use of any type of electronic storage or communication device (including all telecommunication systems, email, and the Web) you are engaged in a type of distance learning. All Computer-Assisted Learning can be considered as a type of distance learning. Whether you are reading this from a hard copy printed document, directly from a CD-ROM or DVD-ROM, or from an electronic copy that has been loaded onto a computer, you are engaged in distance learning.

The 23-page booklet (Watson et al., 2010) may be useful to you in learning more about distance education.

Some Brain Theory

Information from outside one’s body comes into one’s body through senses such as sight, hearing, touch, taste, and smell. The sense organs filter the incoming information, passing some of it into one’s brain and ignoring most of what is sensed.

The brain processes information it receives. Most of this processing takes place at a subconscious level. However, you can focus your attention on incoming information and combine it with stored knowledge in your brain. Through this type of conscious though and focused attention, you can direct your subconscious to
carry out various information retrieval, processing, and storage tasks. This overall process is how problems are solved, tasks are accomplished, and learning occurs.

This is, of course, a highly simplified picture of what goes on. But, think about it in terms of a child listening to a parent or teacher, a child reading a book or viewing a video, a child playing with a toy or a friend, and so on. The child is receiving and processing information that comes from outside his or her brain. Thus, all of these “traditional” forms of informal and formal learning are actually forms of distance learning or distance education. We all engage in distance education during all of our waking moments!

We also all engage in non-distance education. For example, think of person who is immersed in a sensory deprivation tank. Even though there is no sensory information coming in, the person can still think. This thinking can direct the brain’s attention to information that is stored in the brain, and it can result in problems being solved and new information being stored in the brain.

Here is a summary of this somewhat simplified model of learning:

1. All of the learning you do occurs inside your brain and the rest of your body. The learning process is actually occurring at a completely subconscious level—learning involves biological and chemical changes at the cellular level in your brain and in the rest of your body.

2. The data that is processed in a manner that leads to learning can come from internal and external sources. In both cases, the learning that occurs is based on (constructed on) what has been learned in the past.

3. Paying conscious, alert attention to the topics you are trying to learn, reflecting on them, and doing metacognition on them can help direct the learning processes.

Feedback in Learning

Feedback is essential to learning. Feedback can come from internal and external sources.

Here is an internal source feedback example:

I am hungry and as I wander through the woods, doing my “hunter-gatherer” thing, I see some berries that are visually appealing. I cautiously taste and eat one. My taste system and stomach immediately rejects the berry, I gag, and I feel ill. In this one trial learning event I learn to never eat this type of berry again.

Suppose, however, the berry tastes good and my stomach does not reject it. I eat quite a few, and then continue with my hunting and gathering. I eat a variety of
other roots, fruits, and so on. Later in the day I grow ill, throw up, and nearly pass out. The cause or causes may be quite complex. For example, two of the things that I ate may have reacted with each other and produced a poison.

In the second example, my internal feedback mechanism is not up to the learning task at hand. However, a more learned person (such as one of my parents) might know immediately what the problem is and teach me what combination of potential foods to avoid. This is an example of feedback from an external source.

For a more academic example, suppose that you are writing an essay as a school writing assignment. Your brain is directing the writing process, including handing details of forming letters and words on a page or computer screen. From time to time you pause to think about what you have just written. Your brain provides you feedback—giving you its opinion of the quality of the work and changes that might be needed. All of this is an internal feedback process.

However, suppose that you are writing using a word processor with a spelling checker and a grammar checker. They the computer system is providing you with some external feedback.

After your essay is completed, you may have a colleague read it and provide feedback. Your teacher will read the essay and provide feedback. The feedback provided by a colleague or the teacher will likely be of a far different type than that provided by a computer. It is feedback coming from a human being who understands human-to-human communication, understands the meanings that are being communicated, and understands subtle nuances and emotions that are inherent to the communication.

In summary, as we think about learning from external and internal sources of information, we also need to think about feedback from external and internal sources. A good education helps develop one’s knowledge and skills about the eternal and internal aspects of learning.

Think about this as you help your children in making use of informal and formal educational opportunities.

The Medium is the Message

Consider Marshall McLuhan’s statement, “The medium is the message.” In terms of distance education, the medium is the overall area we call Information and Communication Technology. This includes virtual libraries, such as the Web. It includes communication among people and between people and machines. It includes artificially intelligent computer systems that can solve a wide range of Science, Technology, Engineering, and Math problems, as well problems as well as problems in other disciplines.
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The last sentence is particularly important. We have calculators, computer systems, and computerized instruments that can solve a wide range of the problems that we have traditionally taught students to solve using paper and pencil techniques. A number of these aids to representing and solving various types of problems are available free on the Web.

Thus, a computer-based distance learning system does two things:

1. It serves as an interactive medium than can provide information to a learner, receive information from a learner, and act upon the information it receives from a learner.

2. It can provide powerful computer-based aids to solving or helping to solve a very wide range of problems.

Think about these two things the next time you make use of a computer application such as a word processor, graphics package, or a spreadsheet. Such pieces of software include built-in tutorials. That is, they include distanced education provisions designed to help you learn to make use of the computer application.

In addition, such applications software contains built-in Help features. Think of this as a “just in time” type of distance education.

Free Virtual Public Schools

A growing number of states provide free public education coursework online. Indeed, in some cases it is possible to obtain an entire K-12 education through such systems. For information about distance education in the various states, see http://distancelearn.about.com/od/onlinepublicschools/a/OnlinePS.htm

The distance education movement is beginning to have a significant impact on both our precollege and higher education systems of schooling. As an example, starting in fall 2009, precollege students in Florida can do their entire schooling via distance learning. See http://www.flvs.net/ and http://www.orlandosentinel.com/news/local/state/orl-virtual1008nov10,0,978666.story.

Free College-Level Course Materials

A number of educational intuitions are making course materials available free on the Web. People can make use of these free materials to help satisfy their desired to learn. Often the materials include videos of the lectures.

Of course, the institutions making these materials available are not providing free credit for learning the materials. Credits, certificates, degrees, feedback from instructors, and so on cost money!
Many of these courses are suitable for bright high school students who are thinking about going to college. Many are suitable for adults who want to sample some of the best college courses available. All of the courses will introduce you to powerful ideas and ways of thinking that will exercise and stretch your brain. All will provide you with ideas and topics that you can discuss with others, such as your children, grandchildren, students, and friends.

What follows are a few examples of such courses. If the idea of such courses interests you, some Web browsing will help you to find a large number of other courses.

- Massachusetts Institute of Technology. MIT OpenCourseWare (OCW). See [http://ocw.mit.edu/OcwWeb/web/home/home/index.htm](http://ocw.mit.edu/OcwWeb/web/home/home/index.htm)

  This site features video and audio clips, animations, lecture notes, and assignments from MIT courses. Students also will find introductory MIT courses, including chemistry, computers and electronics, engineering, math, and physics. Introductory math classes, for example, include courses on problem solving, mathematics for computer science, single-variable calculus, and linear algebra. Engineering courses include such topics as toy-product design and how and why machines work.


- Carnegie Mellon University. See [http://www.cmu.edu/oli/index.html](http://www.cmu.edu/oli/index.html). Quoting from the Website:

  Bill Gates, chairman of Microsoft Corp. and co-chair and trustee of the Bill & Melinda Gates Foundation came to Carnegie Mellon University on Tuesday, September 22, 2009 for the dedication of the Gates and Hillman Centers at the Pittsburgh campus. As part of his campus visit, Gates, accompanied by Foundation Senior Program Officer Josh Jarrett and Microsoft Corporate Vice President Anoop Gupta, met for nearly 90 minutes with the Open Learning Initiative (OLI) team to discuss the past, present, and future of the project as it moves forward under support from the Bill and Melinda Gates Foundation. [Bold added for emphasis.]

- Education-Portal.com. See [http://education-portal.com/articles/Universities_with_the_Best_Free_Online_Courses.html](http://education-portal.com/articles/Universities_with_the_Best_Free_Online_Courses.html). Quoting from the Website:

  No tuition money? No problem! There are many top universities that offer free courses online. This list ranks several of the best free university courses available for people who want to enhance their personal knowledge or advance in their current field.

- Habitable Planet: Approach to Environmental Science. See [http://www.learner.org/courses/envsci/index.html](http://www.learner.org/courses/envsci/index.html). Quoting from the Website:
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The Habitable Planet is a [free, 13 unit] multimedia course for high school teachers and adult learners interested in studying environmental science. The Web site provides access to course content and activities developed by leading scientists and researchers in the field.

Precollege Courses


• Computer Science Unplugged. See http://csunplugged.com/. Quoting from the Website:

  Computer Science Unplugged is a collection of activities designed to teach the fundamentals of computer science without requiring a computer. Because they're independent of any particular hardware or software, Unplugged activities can be used anywhere, and the ideas they contain will never go out of date. Unplugged activities have been trialled and refined over 15 years in classrooms and out-of-school programmes around the world.

• Lifelong Kindergarten Projects (MIT). See http://llk.media.mit.edu/projects.php. Featured projects include Scratch, Crickets, Computer Clubhouse, Computer Clubhouse Village, and many more. Quoting from the Website:

  At Computer Clubhouse after-school centers, young people (ages 10-18) from low-income communities learn to express themselves creatively with new technologies. Clubhouse members work on projects based on their own interests, with support from adult mentors. By creating their own animations, interactive stories, music videos, and robotic constructions, Clubhouse members become more capable, confident, and creative learners.


• WebQuests. Quoting from http://webquest.org/index.php:

  What is a WebQuest? A WebQuest is an inquiry-oriented lesson format in which most or all the information that learners work with comes from the web. The model was developed by Bernie Dodge at San Diego State University in February
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1995 with early input from SDSU/Pacific Bell Fellow Tom March, the Educational Technology staff at San Diego Unified School District, and waves of participants each summer at the Teach the Teachers Consortium.

Since those beginning days, tens of thousands of teachers have embraced WebQuests as a way to make good use of the Internet while engaging their students in the kinds of thinking that the 21st century requires. The model has spread around the world, with special enthusiasm in Brazil, Spain, China, Australia and Holland.

The Website http://webquest.org/search/index.php provides help in locating WebQuests on a wide range of topics.

• FreeReading. See http://www.freereading.net/index.php?title=Main_Page. Quoting from the Website:

  FreeReading is a free, high-quality, open-source reading program addressing literacy development for grades K-3. Leveraging the collective wisdom of researchers, teachers, reading coaches, and other education and industry professionals, FreeReading provides a high-quality, cost-effective alternative to static materials. By establishing a foundation of hundreds of research-based lessons and materials that users can download and use for free, FreeReading has created the framework for intervention programs supporting K-6 literacy. The collective wisdom within FreeReading is invaluable and can be more beneficial than any one reading program.

Final Remarks

There is now an increasing trend toward use of distance education in both informal and formal education throughout the world. Information and Communication Technology-based education is an everyday activity for many millions of adults and children. It is a steadily growing component of both precollege education and higher education.

We are also seeing some signs of school districts requiring that their students take at least one course via distance education, so that they will experience learning in such an environment.

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9. Telling a Computer What to Do

“Computers are incredibly fast, accurate, and stupid. Human beings are incredibly slow, inaccurate, and brilliant. Together they are powerful beyond imagination.” (Albert Einstein; German-born theoretical physicist; 1879–1955.)

"It goes against the grain of modern education to teach children to program. What fun is there in making plans, acquiring discipline in organizing thoughts, devoting attention to detail and learning to be self-critical?” (Alan Perlis; American computer scientist. 1922–1990.)

Consider a preschool child who has a battery powered train engine or car that runs on a track that the child can assemble. (See Figure 9.1.) The track can be assembled in various shapes. The process of putting designing the track layout and putting the track together is somewhat like programming a computer. The track builder is “telling” the electric train or car where to go. Put the train or car on the track, push the on button or switch, and the train or car automatically follows the directions.

Figure 9.1. Child playing with a toy train. Photo from fotosearch.

Chapter 6 of this book contains a long section listing a variety of free computer graphics programs. Using such programs consists of telling a computer want you want it to do. There are a number of similarities between computer programming and making use of computer graphics software.

What is a Computer Program?

A computer program is a detailed step by step set of instructions to a computer. A modern computer is a machine that can carry out billions of such instructions per second—without making any mistakes. Computer programming consists of
figuring out how to solve a problem and then writing the detailed instructions
telling the computer what to do to solve the problem.

The fundamental idea of computer programming is that of telling a computer a
set (collection, sequence) of instructions in advance of the computer being asked to
carry out the set of instructions. Primary school students can learn to do this—and
at one time many received instruction in writing computer programs in the
language BASIC or Logo.

There is nothing magical about providing a
set of instructions to a computer. For example,
in playing a game on a computer, a person is
telling a computer what move or action he or she
wants to have the computer accept and process.
When a person is writing an email message and
then sending it, the person is telling the
computer system the message and then directing
the computer to send the message.

However, this level of telling a computer what to do is a very modest challenge
relative to developing a large and complex set of instructions that a computer can
follow to solve a complex and challenging problem. People who call themselves
computer programmers think in terms of the challenge of writing programs that
may be thousands of instructions in length. Indeed, teams of programmers attack
problems that may require a program of millions of instructions in length.

This chapter provides a brief introduction to a few ideas about computer
programming. It provides links and to some free computer programming languages
quite suitable for use by children.

However, you need to be aware that very few young children get started in
computer programming on their own. A helper who knows how to program—be it
a younger child, a peer, an older child, or an adult—is almost always needed in
getting started. With appropriate help, students at the first grade level can make
progress in programming that is quite pleasing to themselves and their teachers.

A Little History About Computer Programming

In the very early days of electronic digital computers, computer programs were
written in machine language—with each instruction telling the computer to carry
out a specific set of operations that were wired into the circuitry. Thus, one
instruction might tell the computer to add the numbers in two of its memory
locations, while a different instruction might tell the computer the memory location
in which to store the result.
The tiniest error in writing and encoding these instructions would lead to the computer getting incorrect answers, or not being able to carry out the instructions. It took about a year of instruction and practice to become skilled at programming in a machine language—and each brand of computer had its own machine language.

Eventually computer-programming languages were developed that were more user friendly—that is, better adapted the needs of humans wanting to use a computer. The first version of FORTRAN became available in 1957, and soon it became available for many different brands of computers. A scientist with a decent background in mathematics could learn to write useful programs in the language FORTRAN with just a couple of weeks of instruction. This represented a huge breakthrough in computer programming.

Over time, computer programming languages and computer systems became still more user friendly. BASIC became available in the mid 1960s, and eventually became a quite popular programming language for both precollege and college students. With proper instruction, grade school students could learn to write computer programs in the language BASIC.

When microcomputers started to become available in the mid to late 1970s, the programming language BASIC was made available on these machines. Millions of students of all ages learned to program in BASIC.

A graphics-oriented programming language named LOGO was also developed for use of students of all ages. With it, even an elementary school student could direct a computer to draw a picture of a car or a rocket ship, and set the model car or rocket ship in motion across a computer screen. See http://en.wikipedia.org/wiki/Logo_%28programming_language%29.

The teaching of computer programming to elementary and middle school students has largely disappeared from the curriculum. High school students in many schools have access to an Advanced Placement computer science course and/or to some introductory computer programming courses. However, a relatively low percentage of students take such a course.

Meanwhile, a number of new computer programming languages have been developed that are well suited to the “modern” needs and interests of children. A later section in this chapter provides information about some programming languages that are available for free download from the Web.
More About Telling a Computer System What to do

When you use a computer, part of what you do is “telling” the computer what you want it to do. This is such a straightforward and routine process that you likely do not think about it as a type of computer programming.

For example, you turn on your computer. This simple act tells the computer to carry out an extensive sequence of actions that we humans often call “booting up.” Computer programmers have developed an extensive set of computer system programs that are called into action when you turn on your computer. The most commonly used set of these programs are called Windows (Operating System), Mac OS X (Operating System) and Linux (Operating System). It is interesting to note that Windows and Mac OS X are sold commercially, while Linux is made available free.

Suppose that you happen to want to make use of the Web. A Web Browser is a computer program for “browsing” (using) the Web. A Browser is a relatively sophisticated computer program. However, people developing a Browser try really hard to make the software “user friendly”—that is, easy to learn to use and easy to use.

There are a number of different Web Browsers. See http://en.wikipedia.org/wiki/List_of_web_browsers. The various Browsers having many features in common but each having some distinct features. Developers of Web Browsers typically make them available free.

You tell a Web Browser what to do by specifying one or more search terms, or by using more advanced instructions. Thus, for example, I can tell Google to search for *David Moursund* or for “*David Moursund*”. The first search will find documents that contain both the word David and the word Moursund. Thus, one of the hits may be an article talking about Sam Moursund and his friend David Jones. A search using the quoted expression “*David Moursund*” will only locate articles that contain the two words David Moursund adjacent to each other and in that order.

Each Web Browser has a number of advanced features for doing still more sophisticated searches. Learning to use the advanced features of a Web Browser is like learning a little bit about computer programming.

Lets continue with a few more examples. A piece of software such as a word processor typically includes a *Preferences* feature. I use Microsoft Word. I can specify the typefaces, type sizes, indents, and so on through the “styles” feature of Microsoft Word. I can set up a different set of styles of each type of document that I write, such as a personal letter, a professional article, a newsletter, and a book.
Moreover, I can tell Microsoft Word to automatically check for and correct some of my common spelling and keyboarding errors. For example, my fingers often keyboard educatoin when I mean education. Telling Microsoft Word to detect and automatically correct certain errors is a type of computer programming.

For a still more complex example, perhaps you have used spreadsheet software. People develop spreadsheet models or representations of various problems, such as a budget or a payroll. Such a spreadsheet may include directions to the computer to add various columns of mummers, create a column of numbers by taking the products of numbers in two other columns, and so on. The directions may make use of the large number of build-in functions in the spreadsheet that are much like the built in functions in a scientific calculator. A more advanced spreadsheet might make use of the “If-Then” decision-making feature that is common in most programming languages.

In summary, modern spreadsheet software is much like a limited-purpose computer-programming language. Mastering its capabilities and uses in much like learning computer programming.

Moreover, developing a spreadsheet model or representation of a problem illustrated the essence of computational thinking, one of the most important educational aspects of using computers. A modern education helps students to learn to think and solve problems using both their own brains and computer brains. This two-brain approach to solving problems and accomplishing tasks is called computational thinking. For more details, see http://iae-pedia.org/Computational_Thinking and http://iae-pedia.org/Two_Brains_Are_Better_Than_One.

Creating Your Own Blog, Wiki, or Website

Millions of children and adults have created their own Blogs, Wikis, or Websites. This is now quite easy to do. It is easy to create Blog or Wiki at no cost. If you want your own Website with a domain name that you select, you will need to pay to get a domain name. This can be done for under $10 per year.

Blog

The term Blog or BLOG comes from “weblog.” A Blog can be thought of as a diary or journal that is made available on the Web for others to read. A person can post text messages, photos, music, and video to their blog.

Use your Web Browser to search on free blog and you will find lots of free hosting sites. To learn more about Blogs, go to http://en.wikipedia.org/wiki/Blog.
Wiki

You are probably familiar with the Wikipedia, a free encyclopedia. The software used for the Wikipedia is available free. More user-friendly and easier to use versions are also available free.

Use your Web Browser to search on free Wiki hosting. You will find a large number of sites that provide free hosting of small Wiki sites and provide detailed information on how to get started. My current favorite free hosting site is PBwiki at http://secure.pbworks.com/. Click on FOR PERSONAL in the menu at the top of the page.

Website


This site guides you through the process. The process begins with getting a domain name. Use your Web Browser to search on inexpensive domain name registration and you will find a number of sites that provide this service. Next, you need a computer site to host your Website. There are quite a few sites that will host small Websites for free. Use your Web Browser to search on free web hosting.

A simple Website is easily created by use of a free template. Use your Web Browser to search on free Website templates. Or, you can spend some time learning to design your own Website.

A still simpler way to get started is to enlist the help of a friend who has already gone thorough the steps listed above.

You have probably noticed that some Websites are better designed and more user friendly than others. Many people make their livings in designing high quality, user friendly Websites. Thus, you can hire someone to do this work for you.

However, many free templates (that is, complete Web designs) are available free on the Web. Also, there are many free courses on Web design. A Google search of free online course on Web design will provide you with a number of examples.

Student-oriented Programming Languages

This section lists a few programming languages that are available for free download from the Web. For a much more extensive list, see http://www.freebyte.com/programming/languages/.

Quoting from the http://www.alice.org/ Website:

Alice is an innovative 3D programming environment that makes it easy to create an animation for telling a story, playing an interactive game, or a video to share on the web. Alice is a teaching tool for introductory computing. It uses 3D graphics and a drag-and-drop interface to facilitate a more engaging, less frustrating first programming experience.

Alice is a teaching tool designed as a revolutionary approach to teaching and learning introductory programming concepts. The Alice team has developed instructional materials to support students and teachers in using this new approach. Resources include textbooks, lessons, sample syllabuses, test banks, and more. Other authors have generously joined our efforts, creating additional textbooks.

- **BASIC**: [http://www.nicholson.com/rhn/basic/](http://www.nicholson.com/rhn/basic/). This Website contains information about the free Chipmunk Basic for Windows, Mac OS, and Linux operating systems. Additional free versions of BASIC can be accessed through the Website [http://www.thefreecountry.com/compilers/basic.shtml](http://www.thefreecountry.com/compilers/basic.shtml). Quoting from the [http://www.nicholson.com/rhn/basic/](http://www.nicholson.com/rhn/basic/) Website:

  BASIC (an acronym for "Beginner's All-purpose Symbolic Instruction Code") is the name of a family of related high-level programming languages, developed, circa 1963 at Dartmouth College, to provide an accessible and easy-to-learn environment for non-science students to understand and use computers. In the early 1980's, the Basic programming language was built-in to the majority of personal computers sold.


- **Logo**: [http://www.thefreecountry.com/compilers/logo.shtml](http://www.thefreecountry.com/compilers/logo.shtml). Quoting from the Website:

  The Logo programming language has been used to teach programming to children, as well as to create modeling environments for a variety of purposes. At its most basic form, the language allows you to program a "turtle" to move around the screen, drawing lines as it does so. Some of the implementations below have extended the language in a variety of ways, such as to add multiple turtles, multi-threading, image handling, a 3D world, etc.

  Berkeley Logo ([http://www.eecs.berkeley.edu/~bh/](http://www.eecs.berkeley.edu/~bh/)) is a free implementation of Logo, complete with source code, for Unix, DOS/Windows and Macintosh.

  OpenStarLogo ([http://education.mit.edu/openstarlogo/](http://education.mit.edu/openstarlogo/)) is a version of the Logo programming language that allows you to control thousands of graphic turtles in parallel. The turtles are also able to interact with each other and their world, changing their behaviors according to what they detect.
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  Scratch is a new programming language designed by Mitchel Resnick and his associates at MIT’s Lifelong Kindergarten research group.

  The service is designed for children 8 years old and up to learn the concepts that can be used from an early age for the foundation that allows for the continued learning of programming and other current skills. Helping to form the ability to think creatively, communicate and analyze, use technologies, collaborate, and design, Scratch has been likened to an improved version of Smalltalk, which supposedly offered programming learning tools that operated with the simplicity of building with LEGO pieces. A similar “snap and build” design is used with Scratch as well, and the site is full of other learning tools and resources, such as printable flash cards.

• Squeak: http://www.squeak.org/. Squeak is available for Linux, Mac, and Windows machines. Quoting from the Website:

  Squeak is a modern, open source, full-featured implementation of the powerful Smalltalk programming language and environment. Squeak is highly-portable - even its virtual machine is written entirely in Smalltalk making it easy to debug, analyze, and change. Squeak is the vehicle for a wide range of projects from multimedia applications, educational platforms to commercial web application development. …

  Squeak is an excellent game development platform. Included in Squeak are a number of games to get you started. Of course, being Squeak all of the source code is included, and is ready for reuse. See http://www.squeak.org/Features/FunandGames/.

Final Remarks

Computers are now built into many of our everyday tools. For example, when you use a cell phone you are making use of a powerful computer built into this handheld device. You are communicating with a networked and highly computerized telecommunication system that spans the world.

However, such use of computers and computerized devices is quite far removed from providing a set of finely detailed step-by-step sets of instructions that make up a computer program.

Many children greatly enjoy learning how to do computer programming. This is an empowering approach to learning about some of the capabilities and limitations of computer technology.

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Chapter 10. Robots


1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey any orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Nowadays, quite young children are apt to be exposed to walking, talking toys and other types of interactive robot-like toys and games. Such children adapt easily to the button pushing and other types of activities needed to interact with such toys.

Figure 10.1. ASIMO, a robot.

There are many different types of robots that have been developed and/or under development. See the Wikipedia article at http://en.wikipedia.org/wiki/Robot. For example, a factory robot may well be a machine that is bolted to the floor or to a wall, has an “arm” that includes a paint sprayer, and under computer control spray paints a car body.

Or, a robot may have mobility somewhat like a human being. Such a robot might be able to walk, including walking up and down stairs. It might be able to pick up an object, carry it across a room, and set it down in a designated spot.
Certainly you have heard of an airplane “auto pilot.” This is a computerized device that can fly an airplane. Currently there are a variety of research and development projects on the development of an “auto driver” for a car.

A substantial amount of research is going on to develop artificially intelligent robots. Eventually we will have such robots that can work in a field of crops, doing unsupervised weeding and harvesting.

The actions of a robot are controlled by a computer program. There are now a variety of kits available that students can use to build a programmable robot. Many students are now involved in learning to build and program such robots, and then having their robots compete in various robotic competitions. See http://iaepedia.org/Robotics_and_Education and http://i-a-e.org/iae-blog/robotics-and-robotics-contests-in-precollege-education.html.

**Videos**

There is quite a bit of robot-oriented video material available on the Web. Here are some examples:

  
  This video starts off being about doing extensive exploration in underground caves (where you spend days walking into the caves), but then shifts to talking about space exploration.
  
  This part of the video shows robots currently under development and some visionary robotic ideas for underwater and under ice explorations.
  
  The video explores advances in technology that might someday lead to looking for life in the water under the miles-deep ice covering Europa, one of Jupiter's moons.
  
  The video also explores the possibility of similar equipment being used to explore for water on the moon. It presents a passionate argument for space travel.


- **3:29** Video about a robotic pack animal. See http://www.youtube.com/watch?v=W1czBcnX1Ww.

- **3:26** Video of Sony robots dancing. See http://www.youtube.com/watch?v=9vwZ5FQEUFg&feature=related. Also notice the menu of other robot videos available from this site.

- **7:49.** Robots and artificial intelligence. See http://www.youtube.com/watch?v=P9ByGQGiVMg&feature=related.
Cyber-physical Systems


Scalpels that a surgeon uses to excise small tumors but never actually touches. Robots that can take the place of lab rats in clinical trials. Cars that can drive themselves through busy streets. These were just some of the cutting-edge technologies on display at the Hart Senate Office Building last week as the National Science Foundation (NSF) presented a luncheon briefing and open house for Senate members and their staff on cyber-physical systems (CPS), an emerging technological field that incorporates computing power to improve virtually every facet of modern life.

The basic concept behind CPS is straightforward--combine computing power with existing systems to turn them into "smart" technologies such as airplanes that can detect each other and automatically adjust their flight paths accordingly, or bridges that can sense when they are being overloaded and are in danger of falling down. Experts believe that CPS technologies will increasingly affect our wellbeing, security, and competitiveness, in a variety of areas including aerospace, automobiles, civil infrastructure, energy, finance, healthcare and manufacturing.

Robotic surgery is the use of robots in performing surgery. See http://en.wikipedia.org/wiki/Robotic_surgery. Quoting from this article:

Three major advances aided by surgical robots have been remote surgery, minimally invasive surgery and unmanned surgery. Some major advantages of robotic surgery are precision, miniaturization, smaller incisions, decreased blood loss, less pain, and quicker healing time. Further advantages are articulation beyond normal manipulation and three-dimensional magnification.

MIT Robot Group

MIT’ Media Lab has a Personal Robots Group. Quoting from the Website http://robotic.media.mit.edu/projects/projects.html:

The Personal Robots Group focuses on developing the principles, techniques, and technologies for personal robots. Cynthia and her students have developed numerous robotic creatures ranging from robotic flower gardens, to embedding robotic technologies into familiar everyday artifacts (e.g., clothing, lamps, desktop computers), to creating highly expressive humanoids—including the well-known social robot, Leonardo. Ongoing research includes the development of socially intelligent robot partners that interact with humans in human-centric terms, work with humans as peers, and learn from people as an apprentice.

Robotics Competitions

There are many education-oriented robotics competitions. See an April 1, 2010 list at http://robots.net/rcfaq.html.
Here are links to videos taken at various robotics competitions for students.

- First Robotics Competition. See http://www.usfirst.org/?gclid=ClawqLKtvJgCFRMUagodDCBNZg

  FIRST LEGO League (FLL) is a global program created to get kids excited about science and technology. Geared for ages 9-14 (up to 16 outside of the U.S. and Canada), FLL utilizes theme-based Challenges to engage kids in research, problem solving, and engineering. The cornerstones of the program are its Core Values, which emphasize contributions of others, friendly sportsmanship, learning, and community involvement.

  See video from several of the national contests at: http://video.google.com/videosearch?hl=en&q=first+lego+league&um=1&ie=UTF-8&ei=1ByGSb-LongDQ&sa=X&oi=video_result_group&resnum=5&ct=title#

Final Remarks

Many children learn best in a “learn by doing” environment. Working along side their peers, older children, and adults, they learn to make things and do things. They can see the immediate results of their efforts.

There are many different robotic toys. My 1/9/2011 Google search of programmable robotic toys returned over 60,000 hits. A search restricted to just video-related items returned over 150 hits.

There are now a variety of programming languages, robots and robotic toys, and graphic arts application programs that provide environments in which children can “tell” a computer what they want done. That is, children can learn by doing and see the results of what they have learned and what they are able to do. These types of self-assessment and peer assessment environments are very useful in education.

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Expanding the Science and Technology Learning Experiences of Children

Details are available at the site http://iae-pedia.org/David_Moursund_Legacy_Fund.
There are many topics that could have been included in this book but were not—partly to keep the book manageable in length and not be too overwhelming to readers. This chapter provides brief mention of some of the topics.

**Home Schoolers**

If we define home schooling in a broad enough sense, then every child is home schooled. During the first few years of life, this home schooling is provided by parents, foster parents, siblings, grandparents and other relatives, neighbors, baby sitters, nannies, and so on. Indeed, every person a child encounters can be considered as a teacher—as a source of information and as a provider of interaction and feedback.

In addition, it is important to keep in mind that a significant amount of the non-sleeping time of a student who is regularly attending a public or private school is spent outside of this formal school environment. That is, using a broad definition of home schooling, a majority of the student’s time is spent in a home schooling (outside of a formal school) educational environment.

Some people make a decision to not place their children in public or private schools when the children reach “school age.” Rather, they establish a home school environment, following a curriculum somewhat of their own choice and somewhat governed by state guidelines, rules, and regulations.

The Internet and other Information and Communication Technology are valuable aids to such home schooling. The Web is rich in resources for people doing formal or informal home schooling of children. My 1/9/2011 Google search of the quoted expression “home school” produced nearly million hits.

**Global Warming**

There are a number of major global problems. The video http://www.youtube.com/watch?v=Dtbn9zBfJSS lists some of them and provides a discussion of possibly prioritizing how to use our resources in addressing these problems.
Global warming is a considerable concern to many people. See http://news.nationalgeographic.com/news/2004/12/1206_041206_global_warming.html. In brief summary, there are two main issues. First, are we experiencing global warming? Second, if “yes,” is part or quite a bit of the cause the carbon dioxide and other materials the societies of our planet are releasing into the atmosphere? Here are some education-oriented resources.

**Climate Animations.** See http://epa.gov/climatechange/kids/animations.html. This is a site run by the United States Environmental Protection Agency. Flash animations of Global Warming and Earth Processes intended for grades 5-9.

**Global Warming Kids Site.** See http://epa.gov/climatechange/kids/index.html. The kid's page focuses on the science and impacts of global warming or climate change, and on actions that help address global warming issues. It is designed as a resource for both kids and educators. The site also features games, animations, events, and links to other relevant sites for kids and educators.

**Global Warming Wheel Card Classroom Activity Kit.** See http://www.epa.gov/climatechange/downloads/ActivityKit.pdf. Quoting from the Website:

The U.S. Environmental Protection Agency (EPA) presents the Global Warming Wheel Card Classroom Activity Kit for teachers of grades 6 through 8 who plan to incorporate the topic of global warming into their curriculum. The kit provides resources and activities for using EPA’s Global Warming Wheel Card to educate students about global warming, its sources, and potential impacts. The activity kit also encourages students to think about ways to reduce their individual, family, school, and community contributions to the greenhouse effect.

**Household Emissions Calculator.** See http://www.epa.gov/climatechange/emissions/ind_calculator.html. Use the calculator to obtain a rough estimate of your household's greenhouse gas emissions and explore actions you can take to reduce them.

**Language Translation**

A lot of money, time, and effort have been spent in trying to develop relatively high quality language translation software. This has proven to be a very difficult task. However, quite a bit of progress has occurred over the years. There are now a number of free computer programs available on the Web that will translate from one language to another. You can find some of these programs via a Google search of free language translation. Here are three examples:

- http://babelfish.altavista.com/
- http://translate.google.com/#
Many of the free translation Websites are set up to accept either a block of text presented via cut and paste, or a Web address of a Website to be translated. While the quality of such computer translations has gradually improved over the years, they still leave much to be desired.

If you are fluent in reading two languages, you can check out the quality for yourself. Or, you can have fun starting with some text in one language, having a computer program translate it into another language, and then having the computer translate this result back into the language you started with. You can then compare the original version of the text with the twice-translated version of the text. This activity will likely convince you that language translation by computer still has a long way to go.

**Sounds and Music**

To set the mood for this short section, see the 2:00 video retrieved 1/9/2011 from [http://www.snopes.com/photos/arts/musicmachine.asp](http://www.snopes.com/photos/arts/musicmachine.asp). (You will need to scroll down a bit to find the video.) It gives an interesting example of a musical instrument.

A computer can be used to digitally record, edit, and playback sound. This capability has greatly changed the music recording industry. Now, with relatively modestly priced hardwire and software, a composer can lay down multiple tracks, listen to the results, and edit individual tracks. The composer can also draw on tracks laid down by others.

This brings a new dimension to music education. Even grade school students can learn to use a computer music system to compose and playback music. Here are a couple of sites that might get you and the children you work with started:

- **Dallas Symphony Orchestra Kids.** Retrieved 1/9/2011 from [http://www.dsokids.com/2001/rooms/musicroom.asp](http://www.dsokids.com/2001/rooms/musicroom.asp). The Webpage that you reach is quite active. Move your mouse around to see the active buttons. You can even play the piano. Quoting from the Website:

  The Dallas Symphony Orchestra has started a club just for you... The DSOKids Club!

  The DSOKids club is for those who want to learn more about music and the people who make music. After submitting your information below, you will receive emails (about every other month or so) that will tell you about the exciting things happening at DSOKids.com, such as new games and features.

  To become a member, tell us about how old you are: 12 years old or younger, or 13 years old or older.
http://www.nyphilkids.org/main.phtml. Roll your mouse around to locate active buttons; click on such buttons to get started. Or, and on the sitemap button to get started.

Some Early History of Electronic Music

A number of people experimented with computer-generated music during the early days of electronic digital computers. Quoting from http://en.wikipedia.org/wiki/CSIRAC:

CSIRAC (Council for Scientific and Industrial Research Automatic Computer, pronounced /ˈsɛəræk/), originally known as CSIR Mk 1, was Australia's first digital computer, and the fourth stored program computer in the world. It was first to play digital music and is the only surviving first-generation computer.

The CSIRAC was constructed by a team led by Trevor Pearcey and Maston Beard, working in large part independently of similar efforts across Europe and the United States, and ran its first test program some time in November 1949.

Some Music Sites That Might Interest Children and/or Adults

- Bad Vibes. Retrieved 1/9/2011 from http://sound101.org/badvibes/. Listen to some really bad sounds. This site provides you with an assortment of annoying sounds and allows you to classify each one on the basis of how bad it sounds to you.


  Naomi Lewin brings classical music's great composers to life through music and stories.
Have fun online with classical music games. Compose your own music and share it with your friends; repeat the rockin' rhythms; and listen to the music online.

In the classroom, classical music can be an exciting tool. The Classics for Kids® lesson plans and teaching resources give teachers practical, effective plans and activities that use classical music to help children learn, and meet national and state standards. They are based on National Standards for the Arts and state Academic Content Standards for Music, as well as on Theory of Multiple Intelligences. The materials also incorporate various philosophies, including those of Orff, Dalcrose, and Koda.

- San Francisco Orchestra. Retrieved 1/9/2011 from http://www.sfskids.org/. The San Francisco Orchestra Kids Site provides students with the opportunity to experiment with music composition. The basic elements of music (tempo, rhythm, pitch, harmony, and timbre) are introduced in a fun and interactive environment.

Self-Assessment

Assessment and feedback from the assessment are critical components of learning. For example, as a young child is first learning to talk, the child hears words and attempts to imitate the words. Both external and internal feedbacks occur. An attempted imitation leads to external feedback from the person who spoke the word. Internally, the child hears the sound that he or she has made and compares it to the sound that he or she is trying to imitate.

This internal and external feedback situation continues throughout life. You undoubtedly remember doing math homework problems from a book, and making use of the answers that the book provides for some of the exercises. This is an example of external formative assessment.

You likely have experienced taking tests, and knowing at the end of the test how well you have done. That is, you self-assess your exam performance. Later
you get assessment feedback from the teacher or from the machine that grades the test.

Computer-assisted learning systems (see http://www.k8accesscenter.org/training_resources/computeraided_reading.asp) provide computer-based instruction and feedback. One of the strengths of interactive computer-assisted instruction is that it can provide immediate feedback. That is, in this teaching and learning environment, a computer system assesses the learner’s work and provides immediate feedback. This feedback may include suggestions of possible errors in thinking and understanding and suggestions of possible sources of additional help.

To learn more about computer-based assessment and feedback systems, see:

• http://iae-pedia.org/Self_Assessment
• http://iae-pedia.org/Self-assessment_Instruments

Home Science Experiments

One can do lots of interesting and educational science experiments using materials that are standardly available in a household, or readily purchased at local stores. My 1/9/2011 use of Google produced:

• 2.9 million hits for kitchen biology.
• 10.9 million hits for home biology experiments.
• 1 million hits for kitchen chemistry.
• 2.9 million hits for kitchen physics.
• 9.3 million hits for home science experiments.
• 1.5 million hits for science fair projects.

Needless to say, I did not browse all of these sites. However, I spent some time looking at the home biology, chemistry, and physics sites. Here are a few that I found particularly appealing.

Home Biology

• Fast plants. Retrieved 1/9/2011 from http://www.fastplants.org/. Note that the seeds and other materials are not given away—this is a commercial Website. Quoting from the Website:

What are Fast Plants®? Fast Plants® are a type of crucifer (a large group of plants that includes mustard, radish, cabbage, and more) that have been bred and
selected to have a uniform, short flowering time (14 days) and grow well under in
a small indoor space, with little soil, under artificial lights.

How long is the Fast Plant® life cycle? The entire life cycle for Fast Plants® is
extremely short, and under ideal growing conditions of continuous light, water,
and nutrition, plants will produce harvestable seeds approximately 40 days after
planting.

**Kitchen Chemistry**

  [http://www.uncwil.edu/chem/Courses/Reeves/OnLineLabs/menu.html](http://www.uncwil.edu/chem/Courses/Reeves/OnLineLabs/menu.html). This
  Website was developed using funding from a federal grant. The goal was to
  create chemistry lab experiences that could be done by students taking college
  freshman chemistry via distance education. The labs had to meet rigorous
  standards relative to the traditional on-site chemistry labs in the on-campus
  courses. The site gives details on nine labs.

- Crystal Ornaments. Retrieved 1/9/2011 from
  for several different crystal-growth projects suitable for adult and child working
  together.

- Kitchen Chemistry. Retrieved 1/9/2011 from
  chemistry experiments on your computer. Similar non-virtual experiments can
  be carried out using readily available ingredients.

**Kitchen Physics**


![Figure 11.2. Using a hair dryer to fill a “balloon” with hot air.](image)
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Physics Experiments (n.d.). Retrieved 1/9/2011 from http://www.thenakedscientists.com/HTML/content/kitchenscience/wierd/. This site provides a large number of well-explained examples that can be used with children. Many of the examples include videos.

Education for the Future

This section consists of a copy of the free Information Age Education Newsletter. The issue was published in mid October 2009. The complete collection of these free newsletters is available at http://iae-pedia.org/IAE_Newsletter.

Information Age Education Newsletter

Issue Number 28 October 2009

This free Information Age Education Newsletter is written by David Moursund and produced by Ken Loge. For more information, see the end of this newsletter.

Che sarà, sarà
Whatever will be will be
The futures not ours to see
Che sarà, sarà

It’s a great song. However, many people disagree with the message. For example, Jeff Hawkins and Sandra Blakeslee’s book “On Intelligence” provides a nice description of how a human brain functions by continually making forecasts of the future. Moreover, there are a number of quite respectable university programs in future studies.

Every day you make a number of decisions that involve taking actions based on the decisions. You make a prediction that the decision and action will produce the results you want them to produce. Of course, there is a difference between making such predictions and having the predictions turn out to be good ones.

In addition, there is substantial difference between the challenges of making relatively accurate short-term forecasts and experiencing a reasonable level of success in making longer-term forecasts.

Education and the Future

A kindergarten or first grade student begins school. Our overall educational system has made a decision that this child’s future will benefit by learning reading, writing, and arithmetic. Such forecasts typically include statements about how this education will benefit the country, the economy, and so on. People argue the merits of our educational system in terms of preparing children for responsible, productive adulthood. In summary, education is for the future.

However, we must also think about how education shapes the future. Here is a 1971 widely quote from Alan Kay, a pioneer in the development of laptop...
computers and a major contributor to other aspects of computer science and the field of computers in education:

"Don't worry about what anybody else is going to do… The best way to predict the future is to invent it.” Retrieved 1/9/2011 from http://iae-pedia.org/Alan_Kay.

Thus, as we work to improve our educational system we are faced by a double challenge:

1. Forecasting what the future will be like, so that we can design our educational system to appropriately prepare children for life in this future world that they and others are “inventing.”

2. Understanding that our educational system—including how it is designed and implemented—contributes to changing the future.

An important aspect of this is that our educational system tends to be very slow to change. In many ways, it is a backward-looking system, rooted in the past. Out current educational system has many of the characteristics of the factory model of education developed to serve the needs of industrial age students and countries of a hundred or more years ago.

Our current educational system is challenged by current and predicted future national and world problems such as disease, hunger, homelessness, pollution, population growth, poverty, sustainability, terrorism, war, and so on. As we educate our children to become responsible, productive, caring adult citizens of our country and of the world, we need to think about whether our current educational system is appropriate to the task.

**Reading, Writing, Arithmetic, and Problem Solving**

One way to think about reading, writing, and arithmetic is their roles in representing and solving problems. Reading, writing, and arithmetic are powerful aids to the accumulation of information and to making use of accumulated information to help represent and solve problems in all disciplines.

There are two very important ideas here:

1. The steadily improving aids to the storage, processing, communication of, and communication with the steadily increasing collection of accumulated information.


Think about the first of these two items. The Internet and other communication systems are bringing steadily improving connectivity to the world. You are familiar with the Web as being a dynamic, virtual library that is by far the largest library in the world and that continues to grow very rapidly. The Web is a component of the Internet, and the Internet provides lots of different powerful
aids to communication between people, between people and machines and between machines.

In designing a modern education system, it is reasonable to forecast continued steady improvement in something akin to the Internet and the Web, and in various aids to accessing, making use of, and contributing to the Web.

Thus, we need to look at our current K-12 educational system and analyze it in terms of how well it is preparing students for a responsible and productive adult life in which adults can readily communicate with each other, with machines, and with virtual libraries that are steadily growing “smarter.”

The last sentence brings us to item 2 in the above list. We now live in a world in which information is processed (problems are solved) both by human brains and by computer “brains.” Retrieved 5/3/2010 from http://iae-pedia.org/Two_Brains_Are_Better_Than_One. How well is our education system doing in preparing students for responsible and productive adulthood in a world in which many of the problems and tasks they will face are best addressed by making appropriate use of a combination of human and computer brains? What constitutes a good math education in light of the ready availability of calculators, computers, and computerized tools? This is a very challenging question.

**Some Relevant Forecasts of Information Processing Technology**

Essentially every week brings new announcements of significant progress and/or forecasted progress in Information and Communicating Technology. Retrieved 5/3/2010 from http://iae-pedia.org/What_the_Future_is_Bringing_Us. Computers are getting faster. Storage systems of greater capacity are being developed. Communication systems are getting faster and reaching more people. Information retrieval systems and computer systems are getting smarter.

One way to think about this increase in overall capability and smartness is the improving ability of artificially intelligent systems to directly answer questions and solve problems that people pose. For example, think about the question, “How do I get from where I am now to the nearest pizza eatery?” GPS and related technology on a handheld cell phone can deal with this type of question. Wolfram Alpha has received a lot of publicity for its question answering capabilities, and we can expect that it and other competing systems will steadily improve over time. Retrieved 5/3/2010 from http://www.wolframalpha.com/.

Thus, a good modern education includes a focus on understanding the capabilities and limitations of question-answering computer systems, and how to pose answerable questions.

**Final Remarks**

The previous issue of this Information Age Education Newsletter addressed some aspects of National Standards in education. To a large extent, such proposed National Standards, along with our current focus on state and national testing, are not paying enough attention to the future. In essence, they focus on doing better what we have been doing in the past. The world is changing much more rapidly than its educational systems.
About Information Age Education, Inc.

Information Age Education is a non-profit organization dedicated to improving education for learners of all ages throughout the world. IAE is a project of the Science Factory, a 501(c)(3) science and technology museum located in Eugene, Oregon. Current IAE activities include a Wiki with address http://IAE-pedia.org, a Website containing free books and articles at http://I-A-E.org, and the free newsletter you are now reading.

To subscribe to this twice-a-month free newsletter and to see back issues, go to http://i-a-e.org/iae-newsletter.html. To change your address or cancel your subscription, click on the “Manage your Subscription” link at the bottom of this email message.

Final Remarks

The following two quotes are used earlier in this book:

“Children are the message we send to the future.” (Abraham Lincoln; sixteenth US President; 1809–1865.)

“Children are the world's most valuable resource and its best hope for the future” (John Fitzgerald Kennedy; 35th US President; 1917-1963.)

I feel that these to quotes are well worth rereading from time to time.

Every person is both a teacher and a student. We are all lifelong educators and students. Some of us become professional teachers. In my mind, this includes both parents and “school” teachers at all levels. Through formal and informal education and experience, we teachers can steadily improve our effectiveness. Teaching is a very demanding and challenging informal and formal profession.

Every informal or formal learning situation provides an opportunity to get better at learning to learn, and to learn more about oneself as a learner and as a teacher. Metacognition (thinking about one’s thinking), introspection (getting to learning more about oneself), and reflection (contemplation about what you have done and are doing) are powerful aids to becoming a better learner and teacher. All contribute to greater understanding, transfer of learning, and long-term retention of what you are learning.

I hope that this book has been beneficial to you and the children you work with. Feel free to contact me (David Moursund; moursund@uoregon.edu) via email if you have questions or if you have suggestions for corrections, additions, or deletions to the book.

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References

“Spoken words fly away, written words remain.” ("Verba volant, scripta manent. Latin proverb, possibly from Caius Titus.)

"The strongest memory is not as strong as the weakest ink."
(Confucius, 551-479 B.C.)

This annotated collection of references is intended mainly for adults who want to learn more about education and roles of Science, Technology, Engineering, and Mathematics (STEM) in education. There are a number of resources of particular interest to teachers.


"Triple A-S" (AAAS), is an international non-profit organization dedicated to advancing science around the world by serving as an educator, leader, spokesperson and professional association. In addition to organizing membership activities, AAAS publishes the journal Science, as well as many scientific newsletters, books and reports, and spearheads programs that raise the bar of understanding for science worldwide.

Founded in 1848, AAAS serves some 262 affiliated societies and academies of science, serving 10 million individuals. Science has the largest paid circulation of any peer-reviewed general science journal in the world, with an estimated total readership of one million. The non-profit AAAS is open to all and fulfills its mission to "advance science and serve society" through initiatives in science policy; international programs; science education; and more. For the latest research news, log onto EurekAlert! (http://www.eurekalert.org/) the premier science-news Web site, a service of AAAS.


Directory of Open Access Scholarly Journals in of Education. To the best of our ability to discern, we have included only links to electronic journals that are scholarly, peer-reviewed, full text and accessible without cost. We have excluded professional magazines that are largely not refereed, and commercial journals that may only allow access to a very limited number of articles as an enticement to buy. By restricting membership in this way on the list that follows, we hope to do what little we can to promote free access world wide to scholarship in education.
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Quoting from the Cool Cosmos Website:

In answering the wide public interest in space sciences, NASA has, for more than a decade, made Education and Public Outreach (EPO) an important element in their missions. This “Cool Cosmos” portal is the main gateway of the “Cool Cosmos” EPO group at the Infrared Processing and Analysis Center and the SIRTF Science Center.

The “Cool Cosmos” portal is involving students in science with multi-disciplinary educational materials produced with the goal of engaging the young minds of future generations of scientists. The continuous positive response of the public has been an absolute motivation to create new and innovative methods to reach them. The “Cool Cosmos” team is a dynamic group that has made its vocation to revive the interest, excite the dreams and hopefully answer some of the questions to satiate the public thirst for knowledge of Space.


Standard chess notation is often called algebraic chess notation. It can be used to keep a written record of a game. Quoting from the Website: “Algebraic is now the official format for FIDE (the international Chess Federation), as well as many national federations like the USCF (US Chess Federation). It tends to lead to fewer score sheet errors, and can be more easily read by players from different countries.”


This is a huge and frequently updated collection of information developed and maintained by the United States Central Intelligence Agency. It can be used to retrieve a considerable amount of information about any country or major location in the world. For each country it contains a map and detailed information about the country and its people.


The notion of "concrete," from concrete manipulatives to pedagogical sequences such as "concrete to abstract," is embedded in educational theories, research, and practice, especially in mathematics education. In this article, I consider research on the use of manipulatives and offer a critique of common perspectives on the notions of concrete manipulatives and concrete ideas. I offer a reformulation of the definition of "concrete" as used in psychology and education and provide
illustrations of how, accepting that reformulation, computer manipulatives may be pedagogically efficacious.

Crace, John (1/24/2006). Children are less able than they used to be. *The Guardian*. Retrieved 1/9/2011 from http://www.guardian.co.uk/education/2006/jan/24/schools.uk. Quoting from the article:

New research funded by the Economic and Social Research Council (ESRC) and conducted by Michael Shayer, professor of applied psychology at King’s College, University of London, concludes that 11- and 12-year-old children in year 7 are "now on average between two and three years behind where they were 15 years ago", in terms of cognitive and conceptual development.

"It's a staggering result," admits Shayer, whose findings will be published next year in the British Journal of Educational Psychology. "Before the project started, I rather expected to find that children had improved developmentally. This would have been in line with the Flynn effect on intelligence tests, which shows that children's IQ levels improve at such a steady rate that the norm of 100 has to be recalibrated every 15 years or so. But the figures just don't lie. We had a sample of over 10,000 children and the results have been checked, rechecked and peer reviewed."


This article reports on various research projects done using board games and young children. Quoting from the article:

“There is compelling evidence that certain kinds of board games boost preschool math skills. And these early skills are strongly predictive of math achievement scores later in life (Duncan et al 2008).

For instance, consider the research of Geetha Ramani and Robert Siegler (2008). Ramani and Siegler asked preschoolers (average age: 4 years, 9 months) to name all the board games they had ever played.

The more board games that a kid named, the better his performance in four areas:

• Numeral identification
• Counting
• Number line estimation (in which a child is asked to mark the location of a number on a line)
• Numerical magnitude comparison (in which a child is asked to choose the greater of two numbers).”
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Includes a variety of multimedia materials and “Cool Stuff” such as activities and games designed to help people becoming more knowledgeable about and interested in the field of engineering.


Welcome to the Directory of Open Access Journals. This service covers free, full text, quality controlled scientific and scholarly journals. We aim to cover all subjects and languages. There are now 5,952 journals in the directory. Currently 2,508 journals are searchable at article level. As of today 494,827 articles are included in the DOAJ service.


FREE makes it easier to find teaching and learning resources from the federal government.

More than 1,500 federally supported teaching and learning resources are included from dozens of federal agencies. New sites are added regularly.

FREE is among the most popular K-12 websites maintained by the U.S. Department of Education because of the many great resources being offered by contributing federal agencies.


Research suggests that manipulatives are particularly useful in helping children move from the concrete to the abstract level. Teachers, however, must choose activities and manipulatives carefully to support the introduction of abstract symbols. Heddens divided the transitional iconic level (the level between concrete and abstract) further into the semiconcrete and semiabstract levels, in the following way:

The semiconcrete level is a representation of a real situation; pictures of the real items are used rather than the items themselves. The semiabstract level involves a symbolic representation of concrete items, but the pictures do not look like the objects for which they stand. (Heddens, 1986, p.14).
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“A non-profit organization, IEEE is the world's leading professional association for the advancement of technology.

The IEEE name was originally an acronym for the Institute of Electrical and Electronics Engineers, Inc.

IEEE has:

• more than 375,000 members in more than 160 countries; 45 percent of whom are from outside the United States
• more than 80,000 student members
• 329 sections in ten geographic regions worldwide
• 1,860 chapters that unite local members with similar technical interests
• 1,789 student branches in 80 countries”

The Try Engineering Page at http://www.tryengineering.org/home.php “is a resource for students (ages 8-18), their parents, their teachers and their school counselors. This is a portal about engineering and engineering careers, and we hope it will help young people understand better what engineering means, and how an engineering career can be made part of their future.”


“The International Society for Technology in Education (ISTE) is the trusted source for professional development, knowledge generation, advocacy, and leadership for innovation. A nonprofit membership organization, ISTE provides leadership and service to improve teaching, learning, and school leadership by advancing the effective use of technology in PK–12 and teacher education. Home of the National Educational Technology Standards (NETS), the Center for Applied Research in Educational Technology (CARET), and the National Educational Computing Conference (NECC), ISTE represents more than 85,000 professionals worldwide. We support our members with information, networking opportunities, and guidance as they face the challenge of transforming education.”
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ISTE has developed National Educational Technology Standards (NETS) for students and teachers. See http://www.iste.org/AM/Template.cfm?Section=NETS for profiles of what ISTE believes students should know and be able to do at various grade levels.


A national survey by the Kaiser Family Foundation found that with technology allowing nearly 24-hour media access as children and teens go about their daily lives, the amount of time young people spend with entertainment media has risen dramatically, especially among minority youth. Today, 8-18 year-olds devote an average of 7 hours and 38 minutes (7:38) to using entertainment media across a typical day (more than 53 hours a week). And because they spend so much of that time 'media multitasking' (using more than one medium at a time), they actually manage to pack a total of 10 hours and 45 minutes (10:45) worth of media content into those 7½ hours.

*Generation M²: Media in the Lives of 8- to 18-Year-Olds* is the third in a series of large-scale, nationally representative surveys by the Foundation about young people's media use. It includes data from all three waves of the study (1999, 2004, and 2009), and is among the largest and most comprehensive publicly available sources of information about media use among American youth.


Working memory is used to retain and manipulate information during a short period of time. This ability underlies complex reasoning as well as slightly less complex activities as reading and understanding a sentence.

A number of Klingberg’s papers are available free online (retrieved 1/9/2011) at http://www.klingberglab.se/pub.html.


This article presents a nice introduction to and overview of gratification and the marshmallow test research. On average, young children who deal well with delayed gratification are apt to be much more successful in their lives than those who do not deal well with delayed gratification.

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This Website presents and illustrates the idea of a teacher or a student creating and maintaining a personal electronic filing cabinet in a discipline such as mathematics. It contains examples of the contents of Moursund’s math education electronic digital filing cabinet.


The word game means different things to different people. In this book, I explore a variety of board games, card games, dice games, word games, and puzzles that many children and adults play. Many of these games come in both non-electronic and electronic formats. This book places special emphasis on electronic games and the electronic versions of games originally developed in non-electronic formats.


In this book, “you” means a person perhaps in the 7th or 8th through the 12th grade. Your mind and body are changing rapidly. Most people achieve physical maturity in their late teens. People achieve most of their mental maturity by their mid 20s. With proper physical and mental exercise, your brain will continue to increase in overall capabilities well past middle age. Many people continue to gain in wisdom throughout their lives.

This book will help you move toward achieving your brain’s potentials. It will help prepare you for lifelong learning and effective lifelong use of your brain.


Since its inception in 1958, NASA has accomplished many great scientific and technological feats in air and space. NASA technology also has been adapted for many non aerospace uses by the private sector. NASA remains a leading force in scientific research and in stimulating public interest in aerospace exploration, as well as science and technology in general. Perhaps more importantly, our exploration of space has taught us to view Earth, ourselves, and the universe in a new way. While the tremendous technical and scientific accomplishments of NASA demonstrate vividly that humans can achieve previously inconceivable feats, we also are humbled by the realization that Earth is just a tiny "blue marble" in the cosmos. Check out our "Thinking About NASA History" folder online as an introduction to how history can help you.
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NASA for Students (n.d.). Retrieved 1/9/2010 from http://www.nasa.gov/audience/forstudents/index.html. This site provides access to a tremendous collection of student resources. Examples include:

- NASA for students in grades K–4.
- World Book for students in grades 4–8.
- World Book NASA for middle school and high school students.
- MyNASA. Students 13 years and older may use MyNASA to help with homework and projects relating to NASA.
- NASA Kid’s Club: Play Fun Gamers.


This document is a code of best practices that helps educators using media literacy concepts and techniques to interpret the copyright doctrine of fair use. Fair use is the right to use copyrighted material without permission or payment under some circumstances -- especially when the cultural or social benefits of the use are predominant. It is a general right that applies even in situations where the law provides no specific authorization for the use in question -- as it does for certain narrowly defined classroom activities.


“The National Council of Teachers of Mathematics is a public voice of mathematics education, providing vision, leadership and professional development to support teachers in ensuring equitable mathematics learning of the highest quality for all students.”


“Headquartered in Arlington, Virginia, the National Science Teachers Association is a member-driven organization, 60,000-strong. We publish books and journals for science teachers from kindergarten through college. Each year we hold four conferences on science education: three regional events in the fall and a national gathering in the spring. We provide ways for science teachers to connect with one another. We inform Congress and the public on vital questions affecting science
The NSTA has developed recommendations on national standards for science education. See http://www.nsta.org/publications/nses.aspx.


The National Academies Press (NAP) was created by the National Academies to publish the reports issued by the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council, all operating under a charter granted by the Congress of the United States. The NAP publishes more than 200 books a year on a wide range of topics in science, engineering, and health, capturing the most authoritative views on important issues in science and health policy. The institutions represented by the NAP are unique in that they attract the nation's leading experts in every field to serve on their award-winning panels and committees. This is the right place for definitive information on everything from space science to animal nutrition.

We offer many titles in electronic Adobe PDF format. Hundreds of these books can be downloaded for free by the chapter or the entire book, while others are available for purchase. Our frequently asked questions guide answers questions about purchasing and accessing our electronic books. [Bold added for emphasis.]


Now, at last, technology is catching up to virtual field trips' possibilities. A new generation of trips is merging highly interactive Web sites with engaging storytelling, vibrant art, and curricula tied to national standards, creating a compelling way to explore the natural world without leaving campus.

Here are our top four picks—and you can't beat the admission price: free.


Since the public launch in May 2007, the Scratch Web site has become a vibrant online community, with people sharing, discussing, and remixing one another's projects. Scratch has been called "the YouTube of interactive media." Each day, Scratchers from around the world upload more than 1,500 new projects to the site, with source code freely available for sharing and remixing. The site's collection of projects is wildly diverse, including video games, interactive newsletters, science
Expanding the Science and Technology Learning Experiences of Children

simulations, virtual tours, birthday cards, animated dance contests, and interactive tutorials, all programmed in Scratch.

The core audience on the site is between the ages of eight and 16 (peaking at 12), though a sizeable group of adults participates as well. As Scratchers program and share interactive projects, they learn important mathematical and computational concepts, as well as how to think creatively, reason systematically, and work collaboratively: all essential skills for the 21st century. Indeed, our primary goal is not to prepare people for careers as professional programmers but to nurture a new generation of creative, systematic thinkers comfortable using programming to express their ideas.


Generation M²: Media in the Lives of 8- to 18-Year-Olds is the third in a series of large-scale, nationally representative surveys by the Foundation about young people’s media use. The report is based on a survey conducted between October 2008 and May 2009 among a nationally representative sample of 2,002 3rd-12th grade students ages 8-18, including a self-selected subsample of 702 respondents who completed seven-day media use diaries, which were used to calculate multitasking proportions.


HighWire Press is the largest archive of free full-text science on Earth! As of 1/9/11, we are assisting in the online publication of 2,148,106 free full-text articles and 6,484,696 total articles. There are 22 sites with free trial periods, and 47 completely free sites. 284 sites have free back issues, and 1237 sites have pay per view!


"As manipulatives and cooperative groups become more widely used in mathematics classes, I wanted to know whether students perceived these aids and situations as being useful learning tools. Three-fourths of the students thought that using manipulatives when learning a new mathematical concept was helpful. Most of the comments indicated that using manipulatives first helped students see the origin of the numbers in the formulas. Fewer than one-fourth of the students said that manipulatives were not helpful learning tools, stating that they were confusing."


Page 136
Competition vs. Cooperation

Humans seem preoccupied with the question, "Who is best?" In chapter 5, we talked about feeling anxious and inadequate in some tasks (relative to other people). In chapter 6, we dealt with depression and feeling inferior (as a person) to others. In chapter 7, the topics were hostility, discrimination, and feeling superior to others. In chapter 8, there was an extended discussion of dependency and women's socially assigned subordinate roles. Over and over it appears as though we are thinking about "Who is on top?" and "How do I measure up?" This destructive, competitive, win-lose situation, discussed fully by Kohn (1986), is connected with personally feeling superior--chauvinistic--or inferior to others.


Wikipedia is a free, web-based and collaborative multilingual encyclopedia, born in the project supported by the non-profit Wikimedia Foundation. Its name is a portmanteau of the words wiki (a technology for creating collaborative websites, from the Hawaiian word wiki, meaning "quick") and encyclopedia. Wikipedia's 17 million articles (over 3.5 million in English) have been written collaboratively by volunteers around the world, and almost all of its articles can be edited by anyone who can access the Wikipedia website. Launched in January 2001 by Jimmy Wales and Larry Sanger, it is currently the most popular general reference work on the Internet.


As technology has played a bigger role in our lives, our skills in critical thinking and analysis have declined, while our visual skills have improved, according to research by Patricia Greenfield, UCLA distinguished professor of psychology and director of the Children's Digital Media Center, Los Angeles.

Learners have changed as a result of their exposure to technology, says Greenfield, who analyzed more than 50 studies on learning and technology, including research on multi-tasking and the use of computers, the Internet and video games.

Reading for pleasure, which has declined among young people in recent decades, enhances thinking and engages the imagination in a way that visual media such as video games and television do not, Greenfield said.
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