

Becoming More Responsible for Your Education

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Summary (Preface)

This short book was written for students in their early teens. Many other students, their teachers, and their parents can benefit from it.

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.

Education, training, and experience prepare you to deal with situations you will meet or create. However, there is a challenge in working to obtain a better education. The challenge is the choice between immediate and delayed gratification.

You’ve made this choice many times in the past. You will make this choice many, many times more. For example, learning uses time that you might be using to do other things. Some of the other things will be more fun and less work. They will bring more immediate gratification. This is not to say that delaying gratification is always better. For one thing, a pleasant experience delayed could mean never experiencing that pleasure.

Sometimes you may find it difficult to be responsible for your future. It is not easy to think about the future consequences of the decisions you make every day. It is hard to make realistic plans that will take years to achieve. However, with practice, you can get much better at taking responsibility for your future.

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An important part of your future depends on learning to make use of the collected knowledge of the human race. Physical libraries hold much of this in books, magazines, maps, and so on. Virtual libraries hold more and more of this knowledge. Computers can help you access, process, learn, and use the information.

As an example, think of a static physical book compared to an interactive, computerized book. The computerized book may be very easy to access. It may contain computer-assisted instruction. In addition, it can solve many of the kinds of problems it is teaching about. The physical book may be more portable and more comfortable to use. I may be old-fashioned, but at the current time, I'd rather curl up in bed with a good book than a good laptop display.

Now, think about robots. Robots are computers with some input and output devices they can control. Robots have a type of “brainpower” very different from human brainpower. This type of brainpower is called artificial intelligence (AI).

Machines with AI can do lots of things faster and better than humans just using their human brains. Humans can do lots of things better than robots. Nowadays, many problems are being solved by the combination of human and artificial intelligence. The capabilities of computers and robots are increasing very rapidly. A good education will prepare you to effectively use both human and computer capabilities.

Your adult life will include helping to deal with problems far beyond what any one person can solve. An example is the problem called sustainability. Each of us uses and contributes to the resources of our planet. Each of us is capable of developing a life style that helps to solve the problem of sustainability—or that increases the problem. As you learn to take more responsibility for yourself, you also need to be learning to take more responsibility for our planet Earth. To learn what might happen if we fail to solve the sustainability problem, look up the quoted expression “*population crash*” on the Web.

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About David Moursund, the Author

“The wisest mind has something yet to learn.” (George Santayana; 1863–1952.)

"If I had eight hours to chop down a tree, I'd spend six sharpening my axe." (Abraham Lincoln; 1809–1865.)

Warning to readers: Experts in the field have not peer reviewed this book. It is important you learn to judge for yourself the quality of the information and learning sources you use. Some information about me may help convince you that I am a reliable source of information.

- Doctorate in mathematics, University of Wisconsin-Madison.
- 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 50 books and several hundred articles.
- Major professor or co-major professor for than 75 Ph.D. students.
- For more information about David Moursund, go http://iae-pedia.org/David_Moursund.

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Chapter 1: Getting Started

“The longest journey begins with the first step.” (Ancient Chinese proverb.)

"Learning without thought is labor lost." (Confucius, 551-479 B.C.)

This chapter will help you decide whether you want to read the rest of the book. Each chapter begins with one or more quotations. The first one above is straightforward. What about the second one?

Confucius lived about 2,500 years ago. He was a wise man, and he is still often quoted. Do you suppose his statement means the same to you as it does to other people you know? How is it possible that Confucius said something 2,500 years ago that people believe is still worth thinking about?

By the way, who was Confucius? In reading a book such as this, does it occur to you to ask yourself questions? Does it occur to you to use the Web to help find answers to your questions? An answer of “yes” to the last two questions is good evidence that you are taking responsibility for your own education.

Can you think of some arguments against the two quoted statements? Your mind is capable of learning to argue both (or several) sides of an issue. It is capable of understanding other people’s points of view. It is capable of learning to deal with very challenging problems, such as war, starvation, homelessness, and environmental issues.

Throughout this book, I will be encouraging you to spend more time thinking as you attempt to learn new things. This thinking will help you to learn better. In addition it will help you to get better at learning. It will help increase the capabilities of your brain and mind.

Your brain is one of human’s distinguishing organs; we have more brain compared to body weight than any other animal on earth ever has. As your brain grows and gets educated, it develops a mind of steadily increasing capability. Very roughly speaking, your mind is your consciousness and self-awareness, the pattern of who you are. However, brain and mind are very complex topics. To avoid getting bogged down in this topic, I will usually just use the term brain/mind.

Intended Audience

I wrote this book specifically for adolescent students. Emotionally and physically, you are becoming an adult. Mentally, your brain/mind is switching

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from thinking as a child does to thinking as an adult does (maturely, logically, and responsibly).

This book focuses on helping you to develop an adult mind. You know that your brain/mind has changed a lot since you were a toddler. The path toward having a mature, adult brain/mind is long. In terms of years, the second half of this process occurs during the time a person is about 12 to 25 (or more!) years old.

It is during this age span that one begins to “think” like an adult. Thinking begins to be more systematic and abstract. One’s brain/mind gets much better at the logical use of symbols (i.e., words, math and science symbols, music symbols). Use of such symbols aids in dealing with abstract concepts and complex problems. A person gains increased skill in seeing others’ points of view and in arguing several sides of an issue.

You can find lot of research on the capabilities of an adult brain/mind. One of the things we know is that developing a highly capable, mature adult mind depends heavily on one’s informal and formal education. Because of this, many adults throughout the world have not achieved this level of mental maturity. In many ways, their minds function like those of young high school students.

This is similar to developing your physical capabilities. If you are physically lazy, your innate physical abilities will be underdeveloped. If you are mentally lazy, your innate mental abilities will be underdeveloped. There is a difference: If you are physically underdeveloped, you can still perform common physical tasks. If you are mentally underdeveloped, some mental operations will be completely beyond you. For example, you will be able to run even if you can only run for a short distance. However, you might be utterly unable to figure out which of two credit card offers is better, if either is.

Goals of Education

A healthy human brain/mind is naturally curious. It is learning all the time, and it has a huge capacity to learn. You’re learning when awake or asleep, in school and out of school.

Here is a brief summary of some educational goals that you might want to consider for yourself:

1. Learn facts. Understand how they’re related, weaving them into the pattern of your mind. A mind rich with facts is a mind that can bring more resources to bear on varied and complicated problems.
2. Learn to make use of some tools. Some tools are designed to help your physical capabilities. Examples include bicycle, hammer, and

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microscope. Some tools are designed to help your mental capabilities. Examples include reading, writing, and math. Computers fall into both categories, since they can be used to help automate both physical and mental processes. Tools make many activities more efficient, not to mention possible.

3. Learn to be a creative thinker and problem solver using your physical and mental capabilities, and the aids provided by 1 and 2.
4. Learn to be an effective, efficient learner and to take responsibility for your own learning.

The Devil is in the Details

If you thoroughly understand 1–4 given above, and if you are already doing a good job of carrying out these learning tasks, you may have better things to do than continuing to read this book. However, you have probably heard that “the devil is in the details.” It’s easy enough to read the four-item list. What is difficult is understanding and implementing the ideas. This book will help you to understand the ideas better and will provide you some help in implementing the ideas.

Every day you get to make decisions about how you will spend your time and energy. You have many possible choices. How do you decide what to do when you are given choices?

This book focuses on why and how you should make conscious choices that are satisfying now and useful throughout your life. The idea is simple enough. The choices you make tend to have both immediate and long-term consequences. You can make choices that will improve your mental and physical capabilities.

Alternatively, you can make choices that contribute little to your long-term mental and physical capabilities. You can even make choices that are detrimental to both. For example, suppose when you’re older you have a special friend named Pat. You decide to get a “Pat” tattoo. You could be embarrassed later on.

This book focuses mainly on helping you to develop your mental capabilities. However, you should know that substantial research says being physically fit is an important part of being mentally fit. John Ratey (2007) is a world leader in this area of research.

Did you just “blip” right past the previous paragraph and the reference and link to Ratey’s work? Or, did you go to the Website and listen to Ratey? The reference to Ratey provides an excellent example of the opportunity you have to take increased responsibility for your own education. You are mature enough to

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take considerable responsibility for your eating and exercise behavior. These behaviors affect your brain/mind and body.

Some Challenges

The reading level of much of this book is about the 7th to 8th grade. However, the content of this book is rather “deep.” It is designed to exercise your brain. It is designed to help you increase your level of mental maturity.

Here is an example. School is a time of formal education. When you are in school, the teachers tell you what to learn and do. Outside of school is a time of informal education. Then, you can often to tell yourself what to learn and do.

If you attend school regularly, than school uses up quite a bit of your time. However, during a year, about three-fourths of your non-sleeping time is spent outside of school. This means that you have a lot of time for informal education, even allowing for personal care, chores, homework, etc.

Now, think about what you want to accomplish during your adult life. Your current day-to-day life, however you spend it, is preparing you for your coming life as an adult. Think about the following questions:

1. Do you use your in school time wisely? Here, *wisely* means “in a manner that helps prepare you so you can accomplish your current and adult goals.”
2. Do you use your outside-of-school-time wisely? Here, *wisely* means “in a manner that helps prepare you to accomplish your current and adult goals.”

These are hard questions, because you are, quite naturally, caught up on what’s happening to you and your world right now. If you can think about these questions, it shows that you have a lot more mental maturity than when you did when you were younger. Well, please believe me, things you are doing now will have a strong influence on your future you, even your future fifty years from now.

When you were a young child, your brain was not mature enough for you to think very well about any future beyond the immediate. Now, however, you are capable of setting personal goals and working toward achieving these goals. With practice, you can get better at setting and accomplishing such goals.

Here is a second example. You have probably heard people refer to a computer as an electronic brain. Your human brain can do some things much better than a computer. A computer can do some things a lot better than a human brain/mind. Here are three questions to think about:

1. What are some things that computers can do much better than you?

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2. What are some things that you can do much better than computers? For example, humans have good insight into what it means to be a human—computers don't!
3. How is the education you are getting preparing you for adult life in a world in which computers are getting more versatile, more “intelligent,” and more and more available?

As a third example, you sometimes think about your thinking. This is such an important idea that it has a “fancy” title. It is called *metacognition*. It turns out that metacognition is one of the keys to learning and to getting better at learning.

Just a little while ago you encountered the question: “What are some things that computers can do much better than you?” Right now, spend a little time thinking about how your mind processed the question. Did you think about some things you know about computers? Did you think about some things that computers are really good at? Did you think about using a calculator to do long division? Did you wonder, “Who cares?”

The thinking you did when you read the question determines what you learned from the question. If you didn't spend time giving a mental answer to the question, then you learned very little by reading the question. If you thought long and hard about the question, then you learned quite a bit about yourself and the impact computers are having on the world.

Education and Your Future

Education is about preparing yourself for your near and further future. What can you be doing now so that you can have the future you want? A good education will help prepare you for the various possible futures you would like to have.

Here are three suggestions:

1. Spend part of your time learning about what the world is apt to be like by the time you become an adult. There is an academic discipline called *future studies*. Some important parts of the future include:
 - computers and robots
 - genetics and genetic engineering
 - nanotechnology the technology of the very very small)
 - globalization—increased world competition for jobs
 - increasing world population and problems of sustainability
 - global warming.

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2. Begin to spend some “serious time” thinking about what you want to be and do when you are an adult. The Web has free career exploration tests that can be useful.
3. Begin to shape your informal and formal education to help you prepare for your future. Average 12 to 15 year olds in industrialized countries can expect to live another 65 years or more.

Final Remarks

Three important ideas in this chapter are:

1. Learn to take increased responsibility for your own education.
2. Metacognition.
3. Planning for and preparing for your future.

If you have read and understood this first chapter, you have the “smarts” to complete high school and beyond. You have the capabilities to achieve an education that will serve you well as an adult. Whether you actually do these things is mainly up to you. I hope you will take responsibility for your own education!

Questions to Ponder

Each chapter in this book ends with a small list of questions to think about. Each provides an opportunity to learn more about a specific topic. Also, each provides an opportunity for you to learn more about your own thinking processes.

1. This chapter mentioned the idea of mental maturity. What do you suppose this means? Are you more mentally mature now than you were a year ago? How can you tell? This is a great topic for self-analysis using reflection and metacognition.
2. Make up a good, hard test question for this chapter, and then answer it. Explain why the question is good. Explain why it is hard. (Hint: A good question checks for understanding. Answering it requires thinking and putting thoughts into a pattern, rather than just memorization.)
3. Name and think about at least one thing in this chapter that you found interesting and relevant to your life.

Chapter 2: Inventing Your Future

“You can lead a horse to water, but you can’t make it drink.” (Old adage.)

Don't worry about what anybody else is going to do. ...
The best way to predict the future is to invent it. (Alan Kay;
born 1940.)

What does the first quotation mean to you? Maybe it reminds you of the many adults who tell you what to do. They say they have your best interests in mind. They say, “It will be good for you.” These adults often are correct. They know some things you don’t know, and they’ve had more experience. However, just because they might be correct does not mean you will do what they say. Perhaps you are not thirsty, or perhaps you don’t like to be told what to do.

Now, how about what Alan Kay had to say? He’s made many pioneering contributions to computer development, including laptops . Throughout his life, he has had visions of what he wanted to do—and he has followed his visions successfully, invented his future.

You too are continually inventing your future, even though you, all by yourself, don’t complete control over your life. This book will help you plan (invent) educational aspects of your future; you will be more nearly in control.

Learning to Read and Reading to Learn

Your reading this book proves you have a good mind and have learned a lot. The intellectual tool (writing) I’m using to communicate with you was invented more than 5,000 years ago. It takes most people a considerable amount of time and effort to learn how to read. For thousands of years after the invention of writing, only a small percentage of the population learned to read.

You’ve been working on your reading and writings skills since...do you remember since when? How did you learn to read? If you’re like most people, your learning began long before kindergarten. You saw your parents and caregivers reading. They read stories to you. They helped you learn the alphabet and the 10 digits. Perhaps they taught you to recognize your printed name and some other words.

In kindergarten and first grade, reading became a big deal. Teachers spent a lot of time helping you learn to read. Going back to the “leading a horse to water”

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adage, your teachers led you to the printed word. They tried really hard to help you learn to read.

Your parents, caregivers, and teachers all strongly believed that it would be good for you to learn to read. They knew reading would be quite useful to you as you grew older. Part of teachers' "learn to read" goal is for students to read well enough so they can use their reading skills to learn new things efficiently.

Think about this in terms of the Web. The Web is the world's largest library. It does not contain all of the world's collected information, but it sure contains a lot. Moreover, it is growing very fast. (See <http://www.useit.com/alertbox/web-growth.html>.) Our education system feels that all students should learn to read well enough so they can take advantage of libraries like the Web. If you want to know something, one option is to read about it.

Now, ask yourself: Have I learned to read well enough so that it is easy to read and understand books, magazines, and other library materials? Am I skilled in looking up stuff on the Web? If yes, GREAT! If not, what am I doing about it? Is my answer, "Not much"? Am I wasting time blaming my teachers? Or, do I blame myself or sell myself short? (Actually reading this book is evidence that you are working earnestly on your reading skills.)

Most Important Idea in This Book

The previous paragraph is the key to this book. The book assumes you're mature enough to begin to:

1. Make personal decisions about what you want to learn and how well you want to learn it. This applies to both school and non-school situations.
2. Make well-reasoned decisions about immediate versus delayed gratification. Poor decisions based on a need for immediate gratification can really mess up your future up to and including causing your death.
3. Judge for yourself if your current level of knowledge and skill meets your current needs and the needs you believe you'll have later on.

Each year, as your brain continues to mature and as you get even better educated, you can get better at doing 1–3 above. **Each year you can take more responsibility for your own education.** This is the most important idea in this book.

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The world is changing and you are changing. How can you know what the world will be like when you are a grownup? How can you know what knowledge and skills will be useful to you?

Many very qualified scholars study events, inventions, and trends in order to make well-reasoned predictions. Some of these futurists get Ph.D.s and become professors of Futures Studies. If you want to see some forecasts about possible futures of technology, go to http://iae-pedia.org/What_the_Future_is_Bringing_Us.

An Example

Suppose you like listening to music. Probably you prefer certain types of music and certain recording artists. Next, suppose that you have some recording, storage, and playback hardware. Now, ask yourself:

1. How did you learn about this music? (Probably not in school.)
2. How did you learn how to collect this music and use your hardware? (Again, probably not in school.)
3. What do you know about the musical artists and their recording groups? Are you satisfied with your level of knowledge?

Of course, not everybody is interested in collecting and listening to music. If doing so interests you, you can build your expertise in this area. In the process, you will learn how to build a collection. You will learn how to learn about recording artists, their recording groups, and the production companies.

If you later become interested in a different type of music, you can use your learning and experience as a starting point for building a different collection and building knowledge in this different area of music. That is, you will have a lifelong set of learned skills that can be transferred to situations in the future.

Expertise

In any area that you know something about, you can think about how good you are in the area. What is your level of expertise? The diagram given in Figure 2.1 gives a way to think about this.

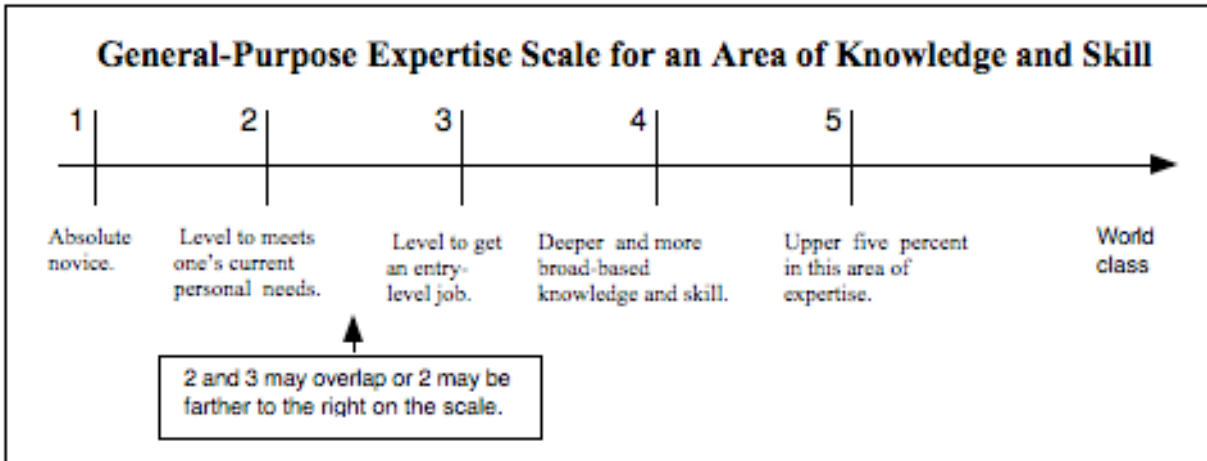


Figure 2.1. An adult-oriented expertise scale.

I call this an adult-oriented scale, because many adults tend to think about getting a good job and having the expertise to do that job well. Notice the label “world class” near the right end of the scale. In your everyday life, you are exposed to world-class athletes, actors, dancers, and musicians. You are less likely to be exposed to world-class engineers, scientists, and other scholars. You might be exposed to world-class bus drivers, custodians, plumbers, real estate agents, salespersons, or servers and have only an idea that “They’re good at what the do.”

Many adults have both a vocation and some avocations. That is, they have a job or other regular activity (such as homemaker) and hobbies. Many artists and musicians, for example, hold a “day job” to make a living so they can afford to pursue their much deeper interest in their avocations. Thus, an adult may well have a higher level of expertise in an avocation than in a vocation.

Final Remarks

A later chapter of this book talks about the time, effort, and drive that it takes to get really good at something. In brief summary, it takes a great deal of time and effort to develop your built-in innate gifts.

If you like to play computer games or other types of games, you may have seen this in your struggles to get to be good in playing a game. Various computer games and board games may take tens to hundreds of hours to learn to play reasonably well. Various sports and intellectual games such as chess, bridge, and poker usually require thousands of hours to achieve a high level of performance, though one may play enjoyably with minimal experience. In various scholarly areas, it may take you 10 to 20 thousand hours to achieve your almost-full potential.

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Thus, I encourage you to start thinking about what you want to become good at. Select one or more areas and begin to put in “serious” time and effort in increasing your expertise in the area.

Questions to Ponder

Each chapter ends with a few questions to ponder. This pondering (thinking) will help you to learn more about yourself. That, in turn, will help you to take more responsibility for inventing your own educational future.

1. Have you decided what you want to do or what you want to be when you become an adult? Do you know some people who are good role models? How might they help you achieve your goals? What are you doing now to help gain the expertise to do what you want to do in the future?
2. Think about two or three things that you are good at (relative to other things you do). How can you tell you are good at something? What did you do to get good at the things you are good at?
3. Most middle school students do not think much about their life expectancy (an estimate of how long you will live).. You’re gaining an education that will be useful to you for a very long time. A number of Web sites can ask you some questions and then estimate your life expectancy. You can experiment, making changes to your answers about eating, exercising, smoking, and so on. This may help you to make good decisions about taking care of your health!
4. Name and think about at least one thing in this chapter that you found interesting and relevant to your life.

Chapter 3: Expertise

"In short, learning is the process by which novices become experts." (John T. Bruer; president of the James S. McDonnell Foundation.)

"Once you have learned how to ask relevant and appropriate questions, you have learned how to learn and no one can keep you from learning whatever you want or need to know." (Neil Postman and Charles Weingartner. *Teaching as a Subversive Activity*, 1969.)

You have many different “islands” or areas of expertise. You’re better at doing some things than other things. This chapter is about expertise—what it is, how to measure it, and how to increase it.

Almost everybody develops a number of the common areas of expertise: Driving a car, tying shoelaces, brushing teeth... Also, almost everybody develops some of the less common areas of expertise. One person might want to be a good carpenter or plumber. Another might want to be good in math and the sciences. A third might want to be good at basketball or ping-pong. A fourth might want to be good at parenting.

In this book, I use the word **discipline** to refer to any area where a person can gain a high level of expertise.

Islands of Expertise

When you’ve thought about a person being an expert, you may have thought about a large, well-known area such as sports, politics, or science. These are huge areas. One can spend a lifetime trying to achieve a high level of expertise in just one small part of these areas.

How about expertise in a smaller area? For example, how about expertise in using a microwave oven, snapping your fingers, or spitting watermelon seeds? These small areas of expertise are called *islands of expertise*. It doesn’t take very long to develop a personally satisfying island of expertise. You have many of them.

Here’s a personal example. Recently I was thinking about how students learn math. I wondered if some students learn math by reading their math books. Then I remembered hearing the phrase “reading across the curriculum.” It is the idea that schools want students to learn to read in the various areas they study in school.

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A few hours of browsing the Web and reading greatly increased my knowledge of reading across the curriculum and reading in math. I found out that many people think it is important for students to learn to read math, so they can learn math by reading math books. I also found out that few students gain this level of math reading expertise before they take college math courses.

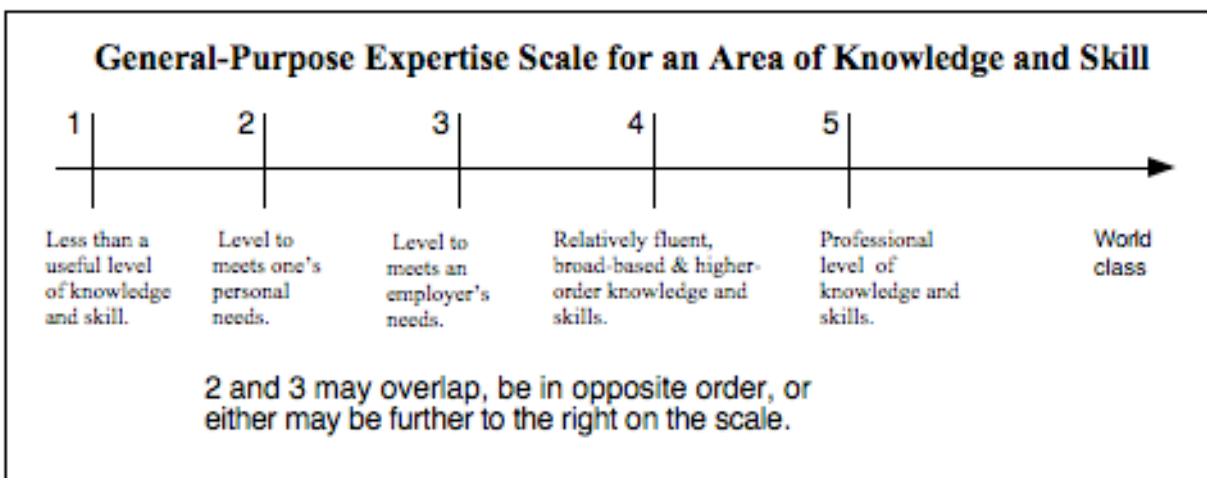
A few weeks later I was at a meeting of math teachers. I brought up the topic. It turned out that in my newly developed island of expertise, I knew more than most of the people at the meeting. I was able to interest some of the teachers in increasing their own level of expertise in this area. Eventually I wrote an article about this topic. More than two thousand people have accessed this article at http://iae-pedia.org/Communicating_in_the_Language_of_Mathematics.

Here's an idea that you might want to try. Each weekend, think back over the week. Identify one of your islands of expertise in which you made use of your expertise, shared your expertise, and increased your expertise. Then identify a new island of expertise that you would like to develop. For example, some weekend you might pick paper airplanes, origami, juggling, or hip hop music. The Web has lots of information you can use to get started in these areas.

Notice that I didn't give you specific Web sites. Part of the process of learning to learn is learning to find the information you need to help you learn. (That's a sentence to read slowly!) Indeed, here are some words of advice. View each learning situation as an opportunity to increase your level of expertise in learning.

Self-assessing Your Expertise

Figure 3.1 is the nearly the same expertise scale as Figure 2.1. The left end of the scale is a person who knows very little about a discipline. At the right end, the person is one of the best in the world in the discipline.



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Figure 3.1. Levels of expertise in a discipline.

Think of a discipline that interests you. Where does it fit on your expertise scale? You probably know people who are lower or higher than you on the scale for this discipline. Now do the same thing for another discipline. Practice until you are fairly good at judging your levels of expertise.

This is one of the really important ideas in the book. You can learn to self-assess. You can decide if your level of expertise in an area meets your needs. You can take personal responsibility for building new islands of expertise and for developing levels of expertise that meet your personal needs. Remember to feel satisfaction that you've achieved these levels.

Competitive people like to compare their expertise against others. Collaborative people tend to think in terms of meeting their personal needs and interests, and then sharing. Some people are very competitive and other people are very collaborative. Most people are competitive sometimes and collaborative sometimes.

Here's a personal story. When I was your age, I enjoyed playing football, basketball, and softball. I was better than some of my peers and not as good as others. I wasn't very good relative to my older brother and his friends.

I spent a lot of time playing these sports. My expertise levels increased through practice, physical growth, and mental growth. However, I was only moderately good. I wore thick glasses, was overweight, had a relatively slow reaction time, and had low dexterity. No matter how hard I tried, I was never going to become a sports star.

During this time, I found other disciplines that interested me. I was good at math, board games, and card games. I learned to play chess and soon became better than many of my friends. Success tends to breed success. Many people are motivated to learn and do the disciplines they can do well.

However, "do well" does not need to be a competitive thing. In many situations, doing well means doing well enough to meet your personal needs. For example, many people read a lot because they experience success in reading for pleasure. What difference does it make if someone I know can read a story faster than me? I am motivated by the fun I get out of reading. I read well enough to enjoy reading.

"Doing well" can mean "helping others do well." Often, if you're lucky, you will have a friend or teammate who is not outstanding but whose presence somehow helps the group or team function better and enjoy themselves more. If

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you are a person who can “do well” in this way, the people you associate with are lucky people.

Nature and Nurture

We’re all born with a wide variety of “gifts” (natural abilities). Each of us has a distinct set of genes. Even identical twins do not have an identical genetic makeup. Nature endows each of us with a unique set of gifts.

Your genetic makeup represents potential. Each person has different potentials. Well before you were born, your environment affected your potentials. A poor environment can damage a person physically and mentally. A lot is known about how poor nutrition, various drugs, lead poisoning, and so on can lead to a newborn having reduced physical and mental potentials.

Both nature (genetics) and nurture (environment) contribute to expertise. As a personal example, my parents were mathematicians. I probably have “good” math genes. I had a strongly supportive math environment that came from my parents and good schools. This combination of nature and nurture helped me as I earned a doctor’s degree in math.

Measuring Levels of Expertise

You have many different areas of expertise. In each, you have some feeling as to how good you are. You can tell if your level of expertise meets your current needs. In any particular area, you can make a good guess as to whether your level of expertise is increasing fast enough so that it will serve you well when you become an adult.

Note that the above paragraph emphasizes expertise relative to meeting your personal needs. Some of your personal needs may be hobbies and other areas not related to getting a job. Some may be in vocational areas in which you might eventually want a career.

In any vocational area, you will be competing with others, so you’ll want to pick possible jobs where you’re apt to have a competitive advantage. (A color-blind person probably should shy away from trying to be a professional interior decorator.) Usually, a job involves a number of different areas of expertise. One type of job may require that you be good at interacting with people. Another type of job may require that you be good at reading and writing. Still other types of jobs may require leadership skills or the ability to complete repeated routine tasks accurately.

If you want to learn more about requirements of various jobs, search the Web for *career information system*. Or, you can be more specific and include the name

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of your state in the search. Many middle schools and high schools offer a career information course and free career information services.

Let's take a specific example. This is the Information Age. A great many jobs require one to be able to learn by reading and to follow written instructions. How well can you read? Many Websites that can help you answer this question. They are designed for self-assessment. For example, the site https://rocketreader.com/cgi-bin/portal/fun_tests/perception is simple and easy to use.

Time It Takes to Achieve Various Levels of Expertise

Consider this quote from Benjamin Bloom, a very famous education researcher.

“After forty years of intensive research on school learning in the United States as well as abroad, my conclusion is: What any person in the world can learn, **almost** all persons can learn if provided with appropriate prior and current conditions of learning.” (Benjamin Bloom, *Developing Talent in Young People*, 1985)

This means you can develop a personally satisfying and useful island of expertise in almost anything you want to do. The opportunities are there. It is up to you to put in the time and effort to take advantage of the opportunities.

Figure 3.2 is a time scale for gaining various levels of expertise.

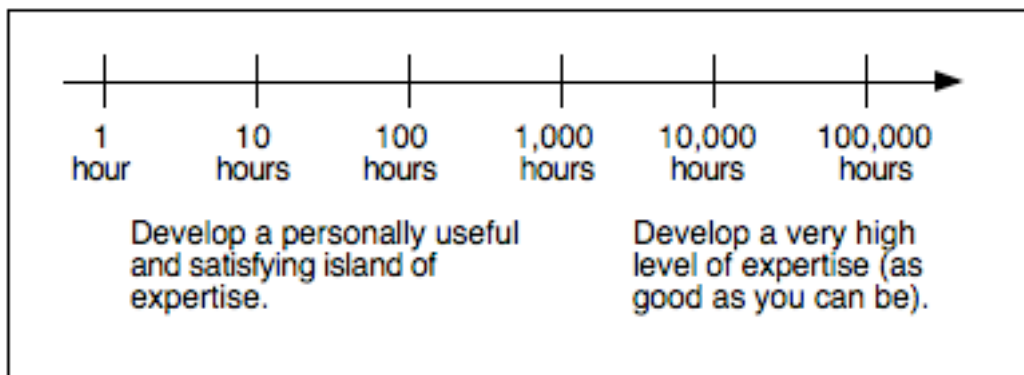


Figure 3.2 Hours of learning and practice to achieve expertise.

It doesn't take very long to move above the absolute novice level in a discipline. For example, suppose that you have never played chess. With a modest number of minutes of instruction, you can learn the rules of the game. With a little more instruction and practice, you can play the game. In the 10 to 100 hour range, you can have an island of expertise that may put you in the upper five-percent of your fellow students.

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Then, with another 15 years or so of hard work (averaging 40 hours or more per week), you can get to be about as good as you will ever be. If your natural gifts in this area are high, you will be world class, doing well in international tournaments.

Many people have studied high level experts and how long it took them to become world class. Depending on the discipline, it takes 10 to 15 years or more. It takes good instruction and coaching. It takes a high level of self-discipline.

In most cases, starting age makes a difference. If you want to be a world-class athlete or scientist, you need to start when you are relatively young. Just for the fun of it, take a couple of minutes to view a video on world-class juggling at <http://www.boreme.com/boreme/funny-2006/best-jugglers-p1.php>. Imagine how many thousands of hours of practice it took the jugglers to get that good! In summary, to become world class in a discipline takes the right combination of both nature and nurture, and it takes many years of hard work aided by good teachers and coaches.

Final Remarks

You have natural gifts in many different areas. You can develop these gifts through study and practice.

Our school system selects some areas in which it wants all students to develop their gifts. Thus, for example, schools feel that all students should learn reading, writing, and arithmetic. Schools feel that all students should learn science and social science. Schools feel that all students should develop skills in interacting with other people and become responsible adults.

Schools touch on only a few areas in which you might want to develop your natural gifts. You have ample time and energy to develop personally useful levels of expertise in many different areas. You get to decide what areas you will pursue.

Questions to Ponder

1. Do you sometimes feel bored? If so, what do you do when you are bored? Do you “waste” the time and opportunity? Or, do you spend time exploring new disciplines, developing new areas of interest and islands of expertise, and improving your levels of expertise?
2. Think about two or three areas in which you’re pretty good. Estimate how many hours you have spent achieving your current level of expertise in each of these areas.

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3. Think about some areas in which you seem to learn rather rapidly. Think about some areas in which you seem to learn rather slowly. Can you give good reasons for these differences?
4. Name and think about at least one thing in this chapter that you found interesting and relevant to your life.

Chapter 4: Problems and Problem Solving

If I have seen further it is by standing on the shoulders of giants. (Isaac Newton; English mathematician & physicist; 1642–1727. Letter to Robert Hooke, February 5, 1675.)

"All progress is precarious, and the solution of one problem brings us face to face with another problem." (Martin Luther King Jr.; 1929-1968.)

Every discipline involves *doing something*. This might be a doing a performance or a presentation. It might be producing a product or inventing something new. It might be solving a problem or accomplishing a task. It might involve collecting, classifying, and storing data or objects.

When I was a young child, I collected pop bottle caps, Popsicle sticks, and tinfoil. In this chapter, I lump all the *doing something* things under the heading, **problem solving**. With that broad definition, problem solving lies at the heart of each discipline. Increasing your expertise in a discipline means increasing your problem-solving capabilities in that discipline.

Problem solving involves using one's emotional, mental, and physical capabilities. It also involves using tools. You've used lots of tools to extend your physical and mental capabilities. Examples include hammers, pliers, bicycles, and fingernail clippers. Other examples include books, whiteboards, crayons, computers, and other mind tools.

Introduction

"*Problem*" means different things to different people. One meaning is "a challenge one wants to overcome." Such challenges come in all sizes. Deciding what clothes to put on in the morning is a problem for some people. It is a very small problem relative to global warming or the fact that hundreds of millions of people live in poverty. On the other hand, you have much more control over what to wear, and how you "overcome" that challenge has a much more immediate effect on your life.

The "hardness" of a problem can change with time. When I was a young child, I had a hard time learning to tie my shoes. I had a hard shoe-tying problem.

Eventually I learned how to tie my shoes. Now, I can solve instances of this problem without conscious thought. Indeed, my shoe tying skills carry over to other areas that involve tying a bow. I now think of tying a bow as a routine exercise rather than as a problem.

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It was worth my personal time and effort to make shoe tying an automatic process so I could do it fast with little or no thinking. Think of some problems you have learned to solve automatically, so you now solve them with little or no thinking.

Did spelling words come to mind? You can spell thousands of words quickly and easily. For each, you have memorized a solution to a “spell-it” problem. Still, there are hundreds of thousands of words that you can’t spell so easily. English has from 200,000 to more than 1,000,000 words depending on how one counts.

I am not good at spelling. I can memorize a list of spelling words in order to pass a test. However, this learning does not stay with me. When faced with the same list a few weeks later, I don’t do very well. I don’t like this “not-good” feeling. However, it is likely part of my genetic makeup—my spelling giftedness may be below average.

Fortunately for me, I have a word processor that has a good spelling checker. My mind tool (computer with spelling checker) and my human mind work together to spell the words I want to use when writing. When I am writing, the real problem I am trying to solve is a communication problem. For me, spelling is a necessary chore if I want to succeed.

Probably you thought of the one-digit arithmetic facts as examples of where you have achieved automaticity in problem solving. You might be quite good at the one-digit times table.

As with spelling, however, some people are not good at memorizing number facts. They may have trouble in memorizing paper and pencil algorithms for multiplication and division. Even if they memorize such an algorithm, they are poor at carrying it out because of their trouble in memorizing the one-digit number facts.

The analogy with spelling and writing is a good one. Doing arithmetic calculations is a necessary part in many math problem-solving situations. Now, of course, we have calculators. They are a wonderful aid to solving calculation problems.

Incidentally, some mental problems seem to require neither words nor actions. Finding one’s way around is an example. Some people unerringly find their cars in a large parking lot and unfailingly can return to a distant address after visiting it once. Others (like me) have a below average level of spatial intelligence giftedness.

What is Problem Solving?

I've written several books about problem solving (Moursund, 2007). For me, problem solving is a complex, interesting, and challenging topic.

Problem solving consists of moving from a given initial situation to a desired goal situation. That is, problem solving is the process of designing and carrying out a set of steps to reach a goal. Figure 4.1 graphically represents the concept of problem solving.

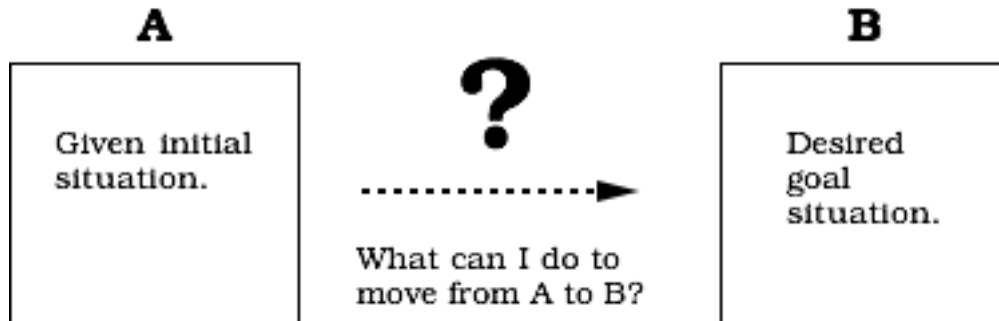


Figure 4.1. Problem-solving—how to achieve the final goal?

In this book, I use the term **problem solving** to include posing, recognizing, clarifying, and:

- answering questions,
- solving problems,
- accomplishing tasks,
- making decisions.

A problem is a thinking and doing challenge. Problem solving requires using critical, logical, and wise thinking. Through study and practice, you can increase your problem solving expertise (attitude, knowledge, and skill).

Many students “tune out” as they listen”to a teacher present information and gives an assignment. At the end of the presentation, the teacher may ask, “Are there any questions?” Usually there are few responses. The responses might even be as self-incriminating as, “What pages did you say we’re supposed to read?”

Now, here is a challenge to you. When the teacher asks for questions, be ready with a deep, challenging, and relevant question that seems important to you. If possible, select one where you have some curiosity and ownership. Think about whether you already know parts of a good answer. Think about whether what the assignment will help you find an answer. You don’t have to ask the teacher the teacher your question, though good teachers delight in students who ask

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challenging questions and who help pursue answers. You can take responsibility for seeking an answer through your own reading and thinking.

The above idea one of the really important ideas in this book. I strongly encourage you to get better at mentally asking “deep, important” questions. When you make up such a question, think about how you can go about finding or creating answers. With continued practice, you can develop a high level of expertise in posing and then answering challenging questions.

Formal Definition of a Problem

As noted earlier, each person has her or his own ideas on what a problem is. The following definition represents the thinking of a lot of smart people. It helps to unify the discipline of problem solving.

The term *problem* is used to refer to a situation where it is not immediately obvious how to reach the goal. The exact same situation can be a problem for one person and not a problem (perhaps just a simple activity or routine exercise) for another person.

Here is a formal definition of the term problem. You (personally) have a problem if the following four conditions are satisfied:

1. You have a clearly defined given initial situation. (See Figure 4.1.)
2. You have a clearly defined goal (a desired end situation). (See Figure 4.1.) Some writers talk about having multiple goals in a problem. However, such a multiple goal situation can be broken down into a number of single goal problems.
3. You have a clearly defined set of resources that may be useful. For example, you have your physical and mental abilities. There may be specified limitations on resources, such as rules, regulations, and time limits. A teacher might say: “This is a closed-book test. You have 30 minutes. Don’t cheat.”
4. You have some ownership—you are committed to using some of your own resources, such as your knowledge, time, and money to achieve the desired goal. Notice that ownership is related to getting gratification from using your resources.

These four components of a well-defined (clearly-defined) problem are summarized by the four words: givens, goal, resources, and ownership. If one or more of these components are missing or hazy, you have an *ill-defined problem situation* rather than a well-defined problem. An important aspect of problem

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solving is realizing when you are dealing with an ill-defined problem situation. Then, your first task may be working to transform it into a well-defined problem.

There is nothing in the definition that suggests how difficult or challenging a particular problem might be for you. Perhaps you and a friend are faced by the same problem. The problem might be very easy for you to solve and very difficult for your friend to solve, or vice versa. Through education and experience, a problem that was difficult for you to solve may become quite easy for you to solve. Indeed, it may become so easy and routine that you no longer consider it to be a problem.

The resources (component 3) of the definition may confuse you. The resources do not tell you how to solve a problem. Resources merely tell you what you are allowed to do and/or use in solving the problem. For example, are you allowed to use the Web or a calculator? Is the test open book or closed book?

The specification of resources may be implied rather than made explicit. Typically you can draw on your full range of knowledge and skills while working to solve a problem. But typically you are not allowed to cheat (for example, steal or plagiarize).

Component 4 (ownership) is often overlooked when talking about problem solving. If you don't care about a particular problem situation, you are unlikely to spend your time and other resources trying to resolve the situation. Many of the problem situations presented in school may seem far removed from your own, personal world. It may seem to you that the assignments and tests try to make you solve problems that are of no interest to you.

There is often a big difference between problem solving in school settings and problem solving outside of school settings. In school, the main goal is for you to get better at problem solving. Most of the examples and problems used are ones that have been used many times in the past. People already know answers to most of these problems. While it may seem to you that your goal is to solve a school problem, your real goal is to learn to solve non-school problems. This will be much harder for you to do if you've decide that your goal in school is to get through it with as little effort as possible so you can get on with "real life."

This situation confuses the ownership issue in problem solving. It may seem to you that many of the school problems are silly. Your attitude may be, "Who cares?" or "I couldn't care less." Thus, you may have little or no ownership of the specifics of a particular assigned problem.

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However, you have a great deal of ownership in your own education and in learning to learn. This type of ownership is applicable to all of the problems you encounter in school class work.

Notice how this shifts the burden of learning to you, personally. The school system and the teacher provide opportunities for you to increase your expertise in solving problems in various disciplines. You get to decide whether you will take advantage of the opportunities.

A Problem Situation is Not Necessarily a Problem

Throughout your daily life, you encounter many problem situations—situations that have some of the characteristics of a problem. However, often they do not satisfy the definition of being a problem for you.

As an example, you see ads for various products. The advertisers tell you that you have a problem that can be solved by buying their product. Before viewing a particular ad, it might not have occurred to you that you have the problem being described. Usually, you can decide very quickly if the problem situation being described concerns you. You can quickly decide whether you have “ownership” of the problem situation. If you don’t, you simply ignore the ad and the situation. It is not a problem for you.

The level of your ownership is also an issue. Are you mildly interested—do you have a low level of ownership? Or, are you very interested—the problem situation is very important to you? How important is it compared to other problem situations you routinely encounter?

One way to think about level of importance is to consider your personal resources. Do you have the time, money, knowledge, and skills to solve the problem? If you use some of your resources on this problem, will this mean you will not have resources you might need in the future for a more important problem?

Another way to think about importance is to consider possible consequences of dealing with or ignoring a problem. Here is a school example. You are taking a required course that does not seem very interesting to you. The teacher gives a homework assignment. You might think, “I couldn’t care less about this assignment. I have no interest or ownership in it.” Thus, you might decide to not do the assignment.

But, what will be the consequences of your decision? Are the consequences of doing the assignment or of not doing the assignment enough for you to take ownership?

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If you don't, it's possible you'll fail to learn something that will be important to you in the future. It's possible that you'll earn a poor grade or even fail the course. This may affect your future.

Schooling is future oriented. Decision-making is also future oriented. Each decision you make may affect your future. Thus, you should strive to make wise decisions! You should practice thinking about possible consequences of your decisions.

Not Every Problem is Solvable

Very many clearly defined problems are not solvable. Here's a simple example from math. Find two positive even integers whose sum is an odd integer. It's easy to prove that this problem does not have a solution.

Here's a problem from science. Build a rocket ship that moves much faster than the speed of light. Our current knowledge of science tells us this problem has no solution. Of course, this problem is routinely solved in science fiction!

How about the problems of homeless people and people dying of starvation? How about global warming and sustainability? These problems feel solvable. However, so far the people of our world have not been able, or willing, to solve these problems.

Final Remarks

This chapter used an example of shoe tying being a problem for young children. With practice, tying shoelaces becomes a memorized procedure, done with little or no thinking. Thus, it is no longer a problem.

An alternative would be to have Velcro to hold the tops of a shoe together. It is much easier to learn to use Velcro than it is to learn to tie a shoe.

Humans are good at inventing tools that solve or help solve problems. An abacus and a calculator provide excellent examples. Thousands of years ago, mentally adding the equivalent of 27 and 48 would be a challenging, probably impossible-to-do, problem for almost everybody. The abacus helped people to do the addition and subtraction they needed to do.

Now we have calculators and computers. They can automatically solve many different problems. That is, many things that used to be called problems are no longer problems—because a calculator or computer can easily solve them.

However, calculators and computers do not take away the challenge of posing or recognizing problems that you might want to solve. They do not take away the challenge of turning an ill-defined problem situation into a clearly defined

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problem. A calculator does not have a human-like understanding of a problem you are trying to solve, so it cannot detect your use of incorrect data, keying errors, or results that make no sense to a person who understands the problem.

In Chapter 6 you'll learn about human thinking versus computer thinking—that is, about human intelligence versus artificial intelligence. You will learn that human minds and computer brains each are important in modern problem solving.

Questions to Ponder

Each chapter ends with a few questions to ponder. This pondering (thinking) will help you to learn more about yourself. That, in turn, will help you to take more responsibility for inventing your own educational future.

1. Think about the givens, goals, guidelines, and ownership parts of a problem. Take a problem that interests you and identify each of these four components. Do this a second time with another problem. Practice this over and over again, until you are good at this task. This will help you to become better at dealing with problem situations.
2. Think of a situation in which you had two different problems you wanted to solve, but had only enough time and money to solve one of them. Explain this in terms of immediate versus delayed gratification.
3. You are at an age when your mind and body are changing quite a bit. You are dealing with the physical changes of going through adolescence. Think of some of the problem situations you are encountering. How well do they fit the formal definition of problem given in this chapter? What are some islands of expertise you might work on to get even better at dealing with these problems?
4. Name and think about at least one thing in this chapter that you found interesting and relevant to your life.

Chapter 5: Problem Overload

“When you are up to your neck in alligators, it's hard to remember the original objective was to drain the swamp.”
(Adage, unattributed.)

"A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty." (Winston Churchill, 1874-1965.)

You may have heard about **information overload**. Humans have collected a lot of information and misinformation. It's stored in lots of different media. More information is added to the Web each day than you could read, view, and listen to in a lifetime. In some sense, there is too much information!

Here is a different way to think about information overload. People use information to help solve problems. They draw upon information stored in their brains and stored in many other ways. Often they cannot find the information they need to solve problems quickly and easily. Indeed, they may have a problem they can't solve. Thus, what they actually have is a **problem overload**.

I like to think of a problem overload as information underload. Perhaps the information we need does not exist. Perhaps we just cannot find and retrieve the information we need.

Most Important Idea in Problem Solving

The most important idea in problem solving is building on the previous work of yourself and others. This is often stated as, “Don't reinvent the wheel.”

There are many ways to build on previous work. As an example, consider people living as hunter-gatherers many thousands of years ago. One of them developed a throwing spear and learned to use it. Others build upon this knowledge and skill. They learned to make their own throwing spears.

Similarly, about 11,000 years ago, a few people learned to plant crops and raise farm animals. Others learned from these initial inventors but not by going to school. Children learned by observing, doing, and receiving feedback from older children and adults, and the environment.

Tools were invented over time to make farming easier. People learned from each other how to make and use these tools. Knowledge was preserved and passed on in the form of how to make and use tools.

Invention of Reading, Writing, and Math

Agriculture allowed population to grow and for the development of cities. It also allowed for specialization. A person could spend a lifetime developing expertise in a narrow area. An apprenticeship type of education developed. People learned a trade by being apprenticed to an expert in the trade.

Larger businesses and cities created problems of record keeping. The need to keep detailed records led to the development of reading and writing. Reading and writing were first invented just a little over 5,000 years ago.

It's not easy to learn to read and write. It takes considerable time and effort to gain a useful level of literacy. Quite soon, the need for readers and writers created a need for schools. In these schools, students, almost always male, came together in a classroom. A teacher taught the class—quite a bit like still occurs today.

Reading and writing allow an accumulation of knowledge and skills far beyond what any one person can learn. As mentioned, more material is published on the Web each day than a person can read and view in a lifetime. Much of it is highly specialized. It takes years of education to have the knowledge and skills to read and understand the latest research in any one specialty of science, medicine, and other many other areas.

Math is another human invention that helps in solving problems. The invention of reading and writing included the invention of written number systems. (Nowadays, we talk about paper and pencil arithmetic. Do you suppose that 5,000 years ago students talked about clay tablet and stylus arithmetic?)

For thousands of years, people who were whizzes at math have been advancing the field, leading to a huge accumulation of math knowledge. Like reading and writing, math is useful in virtually every discipline. Thus, our educational system faces the challenge of helping students gain math expertise at a level that fits their needs and the needs of their society.

Lower-Order and Higher-Order Thinking

You know that some problems are much harder than others. Some problems can be dealt with by rote memorization and require very little thinking. Others require extensive high-level creative thinking.

Figure 5.1 represents the general idea of different levels of thinking.

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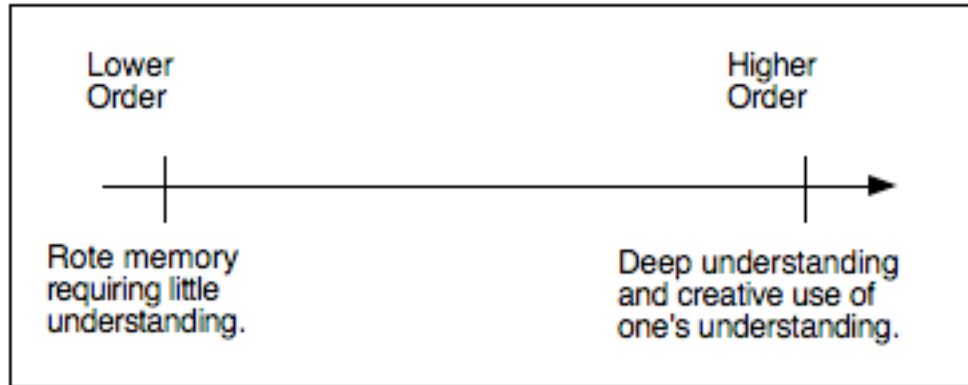


Figure 5.1. Lower-order and higher-order thinking and understanding.

Benjamin Bloom (1913-1999) is famous for a thinking-level scale he helped to develop. This six-level scale is called Bloom's taxonomy. The scale moves from lower-order thinking to higher-order thinking.

1. Recall data (facts) using rote memory.
2. Understand meanings of what one recalls.
3. Apply what one recalls—use in familiar and new situations.
4. Analyze —break a complex problem in to its component parts.
5. Synthesize—put together diverse pieces of one's knowledge and skills in an innovative way.
6. Judge and evaluate, using wisdom and deep understanding.

Our formal education system tries to achieve a good balance between teaching lower-order and higher-order thinking. However, many courses spend much of their time teaching at the lower-order end of the scale, partly because lower-end thinking is easier to test "objectively." This means that relatively little teaching time is spent helping students gain increased expertise in dealing with novel, challenging problems.

Bloom's taxonomy is very general. You can use it to analyze the levels at which you are learning. If you want to make good progress toward developing the potential of your brain, you need to concentrate on higher-order thinking.

Here is a useful way to think about lower-order versus higher order: What you already know and can do well, you can call personally lower-order. What is challenging to you, you can call personally higher-order. In each area that you are developing expertise, there is a dividing line between your current level of expertise and higher levels of expertise.

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Figure 5.2 suggests that you learn best by focusing just a little above where you currently are. Good teaching and learning leads you to move toward a higher level.

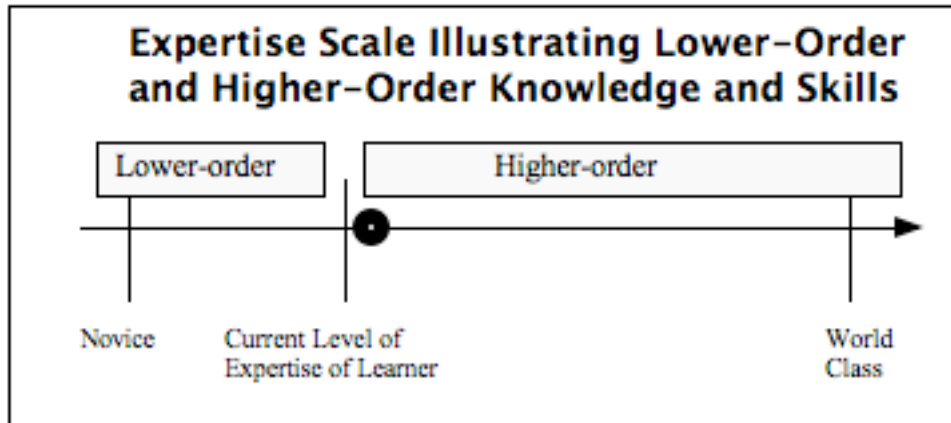


Figure 5.2. The black spot is a desirable target level for teaching and learning.

Transfer of Learning

Reading, writing, and arithmetic are considered to be the basics of education. That is because they are so useful in so many different disciplines. You can learn to use your reading skills in each problem area you encounter. Similarly, you can use the arithmetic you are learning in school to help solve problems of shopping, science, and other areas. Educators call this transfer of learning.

Transfer of learning is one of the most important ideas in education. You learn to solve a particular type of problem. For example, perhaps you have learned what color combinations of clothing go well together. In the future, you can use this knowledge in buying clothing and in deciding what cloths to wear.

But, suppose you are faced by the problem of decorating a room. What colors should you use? It may well be that you can do transfer of learning about dressing yourself to the situation of “dressing” your room!

Transfer of learning is such an important idea in education that researchers have worked on ways to help students learn to do transfer. Here is an example. You are faced by a large problem. By careful thinking, you are able to break this large problem into a collection of smaller problems. You solve each of the smaller problems, put the pieces together, and the large problem is solved.

You probably do this quite often, without thinking about it too much. It is a useful idea in writing. You divide a writing task into smaller pieces by making an outline. It is useful in putting a jigsaw puzzle together. You sort the pieces by

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color, and by edge versus non-edge. In sewing and doing woodworking, you make individual parts and then put them together.

This strategy for breaking a big problem into a collection of smaller problems is often called, “divide and conquer.” This is but one of many important problem-solving strategies.

This is a good place to pause in your reading. Think about some of the problem-solving strategies you routinely use. Can you think of a new strategy that you have learned in the past few months?

When you are solving a problem, think about whether the ideas (the strategy) you are using might be useful in solving other problems. Think about such possible other uses. If you can think of several uses, then give your strategy a name. Practice it with the other situations you have thought of. Make this strategy part of your toolkit of how to attack hard problems.

Here are two general strategies often useful in problem solving:

1. Teamwork. Be collaborative. Working in a team can be quite helpful. With modern telecommunication facilities, the people you seek help from or work with can be located throughout the world.
2. Library research. Do “library” research using the Web and other libraries.

These strategies are useful in many different situations. They can help you solve a wide variety of problems. But, they do not guarantee that you can solve any specific problem. You need to learn when one of these strategies might be helpful. You need to practice using these and other strategies over the wide range of problems you encounter each day.

The following free book contains a long list of problem-solving strategies in an appendix that begins on page 148.

Moursund, David (2008). Introduction to using games in education: A guide for teachers and parents. Access at: http://i-a-e.org/downloads/doc_download/19-introduction-to-using-games-in-education-a-guide-for-teachers-and-parents.html.

A Strategy: Use Personal and Computer Algorithms

It sure would make school easier you could learn just one strategy that would work in solving almost all problems. Maybe that will happen sometime in the future. The strategy might be, “Ask a computer.” Sometime in the future artificial intelligence may get so good that computers will be able to solve most of the problems you encounter. (Whether that would be desirable or not is another matter.)

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However, don't try to hold your breath until this occurs. Right now computers "know" very little about the problems that people encounter in their daily lives. Computers know little about what it means to be a human being.

However, computers are getting "smarter." Here is one way to help understand this increasing smartness of computers. You know some paper and pencil algorithms for doing arithmetic. For example, you know an algorithm for multiplying multidigit numbers. An algorithm is a step-by-step set of directions. If you carry out the directions correctly, you are guaranteed to get a correct answer.

There is a huge collection of algorithms that computers can carry out. Want to know the positive square root of 17? Put the number 17 into a calculator and push the square root key. Want to make a colorful pie chart of some data? Put the data into a spreadsheet and use the graphing feature. Want to see how well two sets of data are correlated (heights and weights for example)? A computer can do this for you. Want to make an animated cartoon character? Computer programs can do much of the work for you. Want to do a frequency count on all of the words in a book? That's an easy task for a computer. Want to change the typeface and size in something you have written? That's an easy task for a word processor.

The point is, that computers can carry out many thousands of algorithms rapidly and accurately. It requires no human-like understanding for a computer to carry out an algorithm. A computer carrying out algorithms is just a "dumb" machine, precisely following directions. In essence, it is functioning at the lowest level in Bloom's taxonomy.

Now, here's a hard question. If a computer algorithm and computerized tools can solve a problem cheaply, fast, and accurately, what should people be learning about solving that problem?

During your lifetime, computers and computerized machines will continue to do more and more things cost-effectively. What kind of education can help prepare you for adult life in this rapidly changing world?

This is not a question that has a simple answer. It is a question that you can hold in your mind as you learn through your formal and informal education. You can shape your education so that it fits your current and future needs. You can take responsibility for getting an education that will help prepare you for the changes that will occur throughout your lifetime.

Here's a start for your personal educational goals: Develop a mind that can settle on worthwhile goals and their relative importance, that settles on principles to live by, and that increases in flexibility.

A Strategy: Use Personal and Computer Heuristics

There are lots of problem-solving strategies that are useful, but are not guaranteed to work. Sometimes they are called, “Rules of thumb.” A more scientific term is **heuristic strategies**. For example, suppose that you need to get up at a certain time tomorrow morning. You can set your clock radio or alarm for that time. That is a useful tactic. But, you might make a mistake in setting the alarm. The power might go off during the night. The clock radio or alarm might break (wear out) sometime during the night. You may sleep through the alarm. “Setting the alarm” is a heuristic.

How do you study for a test? Do you use the same study procedure in all of your courses? Then you make use of only one heuristic strategy. Should you use the same study-for-test heuristic for open-book tests and for closed-book tests? How about for subjects you like versus others you do not like so much? In any case, no study-for-test can guarantee you will get a perfect score on the test.

How do you make friends? Probably you use a variety of heuristic strategies. Your heuristics are useful, but they doesn’t always work as well as you would like.

George Polya (1887-1985) was a world-class math teacher and math problem-solver. He wrote books on how to get better at solving math problems. He developed a heuristic strategy that is useful in math and in many other disciplines. This strategy is worth learning and understanding.

Polya’s 6-Step Heuristic Strategy

The following six-step heuristic strategy is called the Polya Strategy. Note that there is no guarantee that use of the strategy will lead to success in solving a particular problem. You may lack the knowledge, skills, time, and other resources needed to solve a particular problem, or the problem might not be solvable.

1. Understand the problem. You need an initial understanding of the givens, goal, resources, and your level of ownership.
2. Determine a plan of action. This is a thinking, planning activity. What strategies will you apply? What resources will you use? How will you use your resources, in what order will you use them? Are the resources adequate to the task?
3. Think carefully about possible consequences of carrying out your plan of action. Focus major emphasis on trying to anticipate undesirable outcomes. What new problems will be created? You may decide to stop working on the problem or return to step 1 as a consequence of this thinking.

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4. Carry out your plan of action in a thoughtful manner. This thinking may lead you to the conclusion that you need to return to one of the earlier steps. Note that this reflective thinking leads to increased problem-solving expertise.
5. Check to see if the desired goal has been achieved. Then do one of the following:
 - A. If the problem has been solved, go to step 6.
 - B. If the problem has not been solved and you are willing to devote more time and energy to it, make use of the knowledge and experience you have gained as you return to step 1 or step 2.
 - C. Make a decision to stop working on the problem. This might be a temporary or a permanent decision. Keep in mind that the problem you are working on may not be solvable, or it may be beyond your current capabilities and resources.
6. Do a careful analysis of the steps you have carried out and the results you have achieved. See if you have created new, additional problems that need to be addressed. Reflect on what you have learned by solving the problem. Think about how your increased knowledge and skills can be used in other problem-solving situations. Give your mind time to absorb your success.

Many of the steps in this six-step strategy require careful thinking. However, a computer can carry out the work of step 4 in a steadily growing number of situations. The person who is skilled at using a computer for this purpose often may gain a significant advantage in problem solving.

Knowing Yourself as a Learner

Here is another strategy for getting better at solving problems. Learn more about yourself both as a learner and as a problem solver.

For example, it is useful to be able to assess your own learning. You are probably pretty good at judging for yourself how well you have learned something. You can tell if you are meeting your personal expectations. You can tell if your level of knowledge and skill is much less, about the same, or much better than your peers.

Learn about how well and how fast you learn a subject. It is clear that some people learn faster than others, though a fast learner in one area may be slow in another and vice-versa. There has been quite a bit of research on this in various

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academic disciplines. Thus, for example, in middle school one will find some students who learn math less than half as fast as the average student, and others who learn math more than twice as fast as the average student. This means that the really fast learners are more than four times as fast as the slow learners.

However, there is more to learning than just speed. How well do you understand something you have learned? How well can you use your understanding (do transfer of learning) in new situations? How well have you learned to learn and built a good foundation for future learning?

Your answers will vary from discipline to discipline. I believe that one of the most important things you can learn are your strengths and weaknesses as a learner of different disciplines. As you learn about your strengths and weaknesses, you can learn to build upon your strengths and overcome or work around your weaknesses.

Here's a personal example. As noted earlier, I am poor at spelling. However, I am pretty good at thinking out the ideas that I want to write down. In school, I often had to write essay answers to questions. I eventually learned to form an idea in my head and "think" a sentence that I wanted to write. After I had the sentence well in mind, I could then think about whether I could spell all of the words in the sentence. If I couldn't, I rethought the sentence so that it only used words I knew how to spell. Thus I learned to use my thinking skill strength to get around my spelling skill weakness.

Now, of course, I do almost all of my writing using a word processor. I no longer worry much about what words I know how to spell. If I can get somewhat near to the spelling of a word I want into my computer, then my computer and I can usually figure out the correct spelling.

Constructivism: A Learning Theory

There's been a lot of research on how the brain learns, and there are many different theories about learning.

Here's one learning theory. You are used to the idea that teachers teach. They present information they want you to learn. The "empty vessel" learning theory is that a person's brain/mind is like an empty vessel. Teachers can just pour information and knowledge into the brain/minds of their students.

This is a poor, incorrect learning theory. It just doesn't explain how people learn. Teaching based on this idea does not work very well. That's why in this book I'm trying to get you to think about the information I'm presenting. A book that doesn't lead its reader to think is like an exercise machine used as a clothes hanger.

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A good theory helps guide both teachers and learners. Since students vary considerably, a learning theory that is a good fit for one student might not be so good for another student.

Constructivism is the name of an important learning theory. This theory says that you learn by constructing new knowledge on top of and integrated into what you already know.

This theory helps guide both teachers and students. Probably you have noticed that teachers often start a new topic by reviewing some things that they feel you should already know. They're determining if you have the right prerequisites (the right foundation) on which to construct the new learning.

A good lesson provides ample time for students to think, to reflect, to figure out, and to understand: How does the new information fit in with what you already know? Does it agree with what you already know? If so, you can weave it into what you already know. Is it a lot different than what you already know? If so, you will need to construct a new way of looking at things.

The success of this learning process depends on you. Remember: You can lead a horse to water, but you can't make drink. It's your mind. It requires conscious and substantial effort over time to weave new knowledge into what you already know and to construct new areas of knowledge. Good teachers can help make the processes easier. However, unless you are committed to the learning task, little worthwhile learning will occur.

Final Remarks

Problem solving requires both lower-order and higher-order knowledge and skills. You should seek to harmonize your personal needs, interests, and innate abilities. Through study, practice, and personal effort you can get better at whatever you want to do.

There are many ways to get better at solving problems. This chapter contains some big ideas such as strategy, algorithm, heuristic, constructivism, and building on the previous work of yourself and others. It takes quite a bit of effort to internalize such ideas—to make them part of your everyday thinking. It's well worth the effort.

Questions to Ponder

Each chapter ends with a few questions to ponder. This pondering (thinking) will help you to learn more about yourself. That, in turn, will help you to take more responsibility for inventing your own educational future.

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1. Name several algorithms that you use fairly often. Name several heuristics that you use fairly often. Use these examples to explain the difference between an algorithm and a heuristic.
2. You have probably heard the strategy, “Ignore it, and it will probably go away.” Is this an algorithm or a heuristic? Name several examples in which you have used this strategy. How well does this strategy work for you?
3. Give three different recent examples, from three different disciplines, in which you have used the divide and conquer strategy. These need not be from academic disciplines. It’s all right to give examples from your everyday, non-school life.
4. Name and think about (explain) at least one thing in this chapter that you found interesting and relevant to your life.

Chapter 6: Two Brains (Human and Computer) Are Better Than One

"The real problem is not whether machines think but whether people do." (B.F. Skinner, 1904-1990; *Contingencies of Reinforcement*, 1969.)

"Before you become too entranced with gorgeous gadgets and mesmerizing video displays, let me remind you that information is not knowledge, knowledge is not wisdom, and wisdom is not foresight. Each grows out of the other, and we need them all." (Arthur C. Clark; 1917–2008.)

Some people distinguish between brain and mind by an analogy. The “brain” of a computer is hardware, and the “mind” of a computer is software. The brain of a person is wetware, and the mind of a person is the pattern of habits, knowledge and skills stored in this wetware.

The “brain/mind” of a computer is much different than a person’s brain/mind. However, both a human brain/mind and a computer brain/mind can input, store, process, and output information. Both have certain “wired in” capabilities. Both can learn.

This similarity has led people to study human intelligence versus computer intelligence. Computer intelligence is called artificial intelligence (AI) or machine intelligence.

This chapter looks at human intelligence and computer intelligence. The goal is to help you get better at using both types of brain/minds.

By the way, do you know who B.F. Skinner and Arthur C. Clarke were? Each had a major impact on our world. If you are familiar with these two people, you might want to spend some time learning about them.

Human Intelligence

You have a very good brain/mind. This has come about through nature (your genes) and nurture (environment, education.) Here are two key ideas:

1. Your brain/mind will get better as it grows to full maturity. For most people, brain growth is complete by the mid 20s. The mind can grow until ageing or disease impairs the brain.

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2. Your brain/mind gets better through informal and formal education and everyday use. “Use it or lose it” is an excellent heuristic.

You know you are intelligent. You probably know some people who are more intelligent than you, and some people who are less intelligent than you. You also have noticed that you have more natural ability in some areas than in others. For example, music may seem easy and natural for you, while math is hard—or, vice versa.

People have been studying human intelligence for a very long time. Plato wrote this well over 2,000 years ago:

Did you mean to say that one man may acquire a thing easily, another with difficulty; a little learning will lead the one to discover a great deal; whereas the other, after much study and application, no sooner learns than he forgets? (Plato, 4th century B.C.)

Human intelligence is a combination of the abilities to:

1. Learn. This includes all kinds of informal and formal learning via any combination of experience, education, and training.
2. Pose problems. This includes recognizing problem situations and transforming them into more clearly defined problems.
3. Solve problems. This includes solving problems, accomplishing tasks, and fashioning products.

How can you tell how intelligent a person is? It turns out that this is a hard question. Many different people have tried to answer this question.

More than a hundred years ago, Alfred Binet and Theodor Simon developed a useful intelligence test. Their goal was to have a simple way to separate mentally subnormal French children from mentally normal French children. They needed a test that could divide students into two categories.

Binet and Simon discovered that some children learned much slower than others. For example a “slow” eight year old might do as well on their test as an “average” six year old. This led to the idea of dividing a student’s score on the test by the student’s age, producing what is called an intelligence quotient (IQ).

Eventually it became common to scale the test scores so that the average IQ score for students at any particular age was 100. As a student got older, the student had to score more points on the test in order to remain at the same IQ level.

Suppose that you have an IQ of 105. This puts you slightly above average—in the vast middle group of people. As you get older, your brain/mind moves toward

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maturity and you learn a lot. Your intelligence will increase year after year. However, your IQ is apt to remain at about 105.

There are major exceptions to this. IQ can be increased through formal and informal education. If you “push” yourself mentally, your IQ will likely increase. If you push yourself mentally in a specific discipline, your capabilities and expertise in this area will grow considerably.

On the other hand, there are a wide variety of drugs and poisons (such as lead and mercury) that lead to brain damage and a decrease in IQ.

The analogy with physical development is quite good. Athletes push their physical development. They become physically more fit and capable. If you work at it, you can become mentally more fit and capable.

Nature and Nurture

The past hundred years of research on intelligence has led to many new discoveries. A key finding is that both nature and nurture contribute to one’s IQ.

The genetic makeup you got from your biological parents is important. However, even before you were born, your intelligence was being influenced by the quality of food you were receiving. A shortage of certain vitamins, for example, can decrease IQ. The presence of various drugs and poisons such as lead and mercury can decrease IQ.

In addition, informal and formal education makes a big difference. Even a seemingly simple thing such as how much talking infants hear from their parents and other caregivers makes a big difference.

An average brain/mind is naturally curious and has a tremendous ability to learn. Some environments are much better than others in supporting the curiosity and learning abilities. For example, consider a child growing up in a bilingual or trilingual home and community environment. This child will become fluent at speaking two or three languages before starting school.

Mirror Neurons

You may have heard of the expression, “Monkey see, monkey do.” Monkeys, humans, and a number of other animals can learn by imitation. A careful study of this situation led to the discovery of mirror neurons. As you see a person yawn, your mirror neurons get ready to send out a “yawn” command. If you see a person who is crying because they are sad, you are apt to feel sad. Read about mirror neurons at http://iae-pedia.org/Mirror_Neurons. Alternatively, listen to a 14 minute video about this topic at <http://www.pbs.org/wgbh/nova/sciencenow/3204/01.html>. The discovery of mirror neurons is relatively recent. There is a good chance your

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parents and teachers do not know about mirror neurons. Thus, you can relatively easily gain an island of expertise in a very important area of biology—and have a level of expertise that is higher than that of most adults!

Predicting the Future

Your brain is continually predicting the future. This occurs at a subconscious level. Suppose you are walking down some stairs. As you walk, your brain is predicting what it expects will happen. For example, it predicts that your foot will encounter a stair tread. If the actual stair tread is higher, lower, or narrower than predicted, your brain immediately signals that something is wrong (different than predicted).

As you walk into a familiar room, your mind knows (predicts) what it will see. If something has changed (does not meet the predictions), there may first be a sense “something is not right.” Then your conscious mind searches for what is different than expected.

This prediction process is also ongoing as you listen to a person talk. Your subconscious “expects” a certain pattern, often predicting what will be said before it is said.

Your brain “learns” and stores patterns. To a large extent, building expertise is a process of learning patterns that can be used at a subconscious level. A chess master glances at a chessboard position. The chess master’s subconscious mind analyzes the board, looking for familiar patterns. Some of the stored patterns are associated with a message “good—here is a way to exploit this situation.” Other stored patterns are associated with message “bad—watch out, this is a troublesome situation.” The stored patterns and accompanying messages come from thousands of hours of study and practice.

The chess master example is representative of all learning. In each discipline, you gain increased expertise by learning and storing patterns that can be used at a subconscious level.

Developmental Theory

You know that babies seem to want to put all kinds of toys and other things into their mouths. Very young children go through a sensorimotor stage of brain/mind development. Jean Piaget is a famous researcher who studied the stages children go through as their brain/mind matures. Piaget’s 4-stage scale is summarized in Figure 6.1 (Huitt and Hummel, 1998).

Approximate Age	Stage	Major Developments
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Stage 1. Birth to 2 years	Sensorimotor	Infants use sensory and motor capabilities to explore and gain understanding of their environments.
Stage 2. 2 to 7 years	Preoperational	Children begin to use symbols. They respond to objects and events according to how they appear to be.
Stage 3. 7 to 11 years	Concrete operations	Children begin to think logically. They learn about number, length, liquid, mass, weight, area, volume. Increasing intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects.
Stage 4. 11–12 years and beyond	Formal operations	Thought begins to be systematic and abstract. In this stage, intelligence is demonstrated through the use of symbols related to abstract concepts, problem solving, and thinking clearly and logically.

Figure 6.1 Piaget's Stages of Cognitive Development

Notice that the fourth stage (formal operations) begins about the time students start middle school or junior high school. By then, an average person's brain/mind has become mature enough to begin to deal with complex problems. Remember, however, a typical person's brain is not fully mature until about 25 years of age. Also, during adolescence, major hormonal changes are occurring in one's body, which usually significantly affect which aspects of one's environment one pays most attention to.

Every academic area has aspects of abstraction and makes use of careful, logical reasoning. Math and the sciences tend to be challenging to many students. This is partly because of the abstract symbols, and the careful, logical arguments and reasoning used in these disciplines.

The formal operations stage is open ended. In the United States and other industrialized nations, more than half of all students are still far from having reached the mid-level of formal operations by the time they finish high school.

Evidence suggests that extensive, high quality, formal and informal education contribute substantially toward moving from Level 3 into middle range or higher Level 4. What this means to you, personally, is that you have a great deal of control over this occurrence.

Some Theories of Intelligence

One theory of intelligence is that there is a general intelligence factor. It has been named "g." Linda Gottfredson (January, 1998) has written an excellent article about intelligence. Quoting from this Scientific American article:

The debate over intelligence and intelligence testing focuses on the question of whether it is useful or meaningful to evaluate people according to a single major dimension of cognitive competence. **Is there indeed a general mental ability we**

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commonly call "intelligence," and is it important in the practical affairs of life? The answer, based on decades of intelligence research, is an unequivocal yes.

No matter their form or content, tests of mental skills invariably point to the existence of a global factor that permeates all aspects of cognition. [Bold added for emphasis.]

The amount of general intelligence varies from person to person. A person with a high level of general intelligence learns faster and better than a person with a lower level of g.

However, many people believe that a person has different levels of intelligence in different areas. Howard Gardner, for example believes that a person has at least eight different kinds of intelligence (Gardner, n.d.).

- **Bodily-kinesthetic. Movement.** People with a high level of this intelligence are generally good at physical activities such as sports or dance. They often prefer activities that utilize movement.
- **Extrapersonal. Interaction with others.** People with a high level of this intelligence are usually extroverts. They are characterized by their sensitivity to others' moods, feelings, temperaments and motivations, and their ability to cooperate in a group.
- **Intrapersonal.** People with a high level of this intelligence are typically introverts and prefer to work alone. They are usually highly self-aware, introspective, and capable of understanding their own emotions, goals, and motivations.
- **Logical-mathematical.** This area has to do with logic, abstractions, inductive and deductive reasoning, and numbers and other math symbols.
- **Musical.** This area has to do with rhythm, music, and hearing. Those who have a high level of musical-rhythmic intelligence display greater sensitivity to sounds, rhythms, tones, and music.
- **Naturalistic.** This area has to do with nature and ability to be “in tune” with nature and one’s naturalistic surroundings.
- **Verbal-Linguistic.** This area has to do with spoken or written words. People with high verbal-linguistic intelligence display a facility with words and languages. They are typically good at reading, writing, and telling stories.
- **Visual-spatial.** People with high visual-spatial intelligence are typically good at visualizing and mentally manipulating objects. They have a strong visual memory and are often artistically inclined.

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Robert Sternberg has developed a widely accepted theory of multiple intelligences (Sternberg and Grigorenko, 2004). In simple terms, his three-part theory divides intelligence into:

- Analytical intelligence (abstract reasoning and logical thinking).
- Creative intelligence (generating new ideas and dealing with novel situations).
- Street smarts (ability to apply knowledge to the real world).

You can use these two multiple intelligence lists to examine yourself. Are there some items in Gardner's list where you seem to have more natural ability than others? Similarly for Sternberg's list. Professors (for example, your author) are often criticized for living in an Ivory Tower that is far removed from the real world. It is often said that professors have poor street smarts.

Artificial Intelligence (Machine Intelligence)

Computer brains (data processing circuits and quick information retrieval) get better (learn) through the design and construction of faster computers with larger memories. Computer minds (ability to do more tasks more efficiently) also get better through the work of thousands of computer programmers.

The history and folklore of intelligent machines goes back well before the first electronic digital computers (Wikipedia, n.d.; History). John McCarthy coined the phrase artificial intelligence (AI) as the topic of a 1956 computer conference (Buchanan, n.d.). Thus, this discipline is now more than 50 years old. It's made a lot of progress through research and through the development of faster computers.

- . Marvin Minsky, a pioneer in AI, offered this definition in the early 1960s:
“...artificial intelligence is the science of making machines do things that would require intelligence if done by men.”

In brief summary, AI is concerned with developing computer systems that can acquire and store knowledge and effectively use this knowledge to help solve problems and accomplish tasks. This brief statement sounds a lot like one of the commonly accepted goals in human education. Schools help students learn (gain knowledge) and to use this knowledge to help solve problems.

You may have noticed that the definitions of AI don't mention computers' possible sources of knowledge. Two common sources of an AI system's knowledge are:

- Human knowledge that has been converted into a format suitable for use by an AI system.

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- Knowledge generated by an AI system, perhaps by gathering data and information, and by analyzing data, information, and knowledge at its disposal.

While most people accept the first point as being rather obvious, many view the second point only as a product of science fiction. Many people find it scary to think of a machine that in some sense “thinks” and thereby gains increased knowledge and capabilities. On the other hand, probably most people wouldn’t be scared of a robotic vacuum cleaner, even one that “learned” the pattern of a room and its furniture.

How Intelligent is a Handheld Calculator?

Handheld, solar-powered calculators cost from about a dollar to several hundred dollars. The one-dollar 6-function calculators can add, subtract, multiply, divide, and calculate a square root. They have a keyboard for input, memory to store numbers being worked on, and a display for output.

You can argue whether such a calculator displays artificial intelligence. However, you know that it takes a person a long time to learn to add, subtract, multiply, and divide whole numbers and decimal fractions. A one-dollar calculator can do some things that, if done by a human, are considered to be evidence of human intelligence.

A \$15 scientific calculator has a large number of built-in functions and uses scientific notation. In some sense, a scientific calculator is more intelligent than the 6-function calculator.

For about the same cost as a scientific calculator, one can buy a fraction calculator. It can add, subtract, multiply, divide, and simplify fractions.

A graphing calculator costing about \$100 can draw graphs and solve equations. It can also do all the things a scientific calculator can do. Thus, in some sense it is more intelligent than a scientific calculator.

A still more expensive calculator may have all of the features of a full-blown desktop computer. Again, in some sense, it is more intelligent than a graphing calculator.

This sequence of calculator examples helps give a picture of different levels of AI. But, the AI is very narrow. If a person could only do the types of things a calculator can do, we would call the person a math savant. A typical human can do many things besides math calculations.

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More Intelligent AI Systems

In the early history of AI, researchers looked for some problems that many people could understand, and that are hard for humans to solve. A number of AI researchers decided to study the game of chess. Could a computer program be developed so it could play a good game of chess? Could a program be developed that could play as well as a very good human player?

This turned out to be a major challenge. After many years of effort, chess programs were developed that could beat low level human players. Computer chess tournaments were held between the various chess programs. Eventually, computers were allowed to play in some human tournaments. In 1997, a computer beat Garry Kasparov, the world's best human chess player (Deep Blue, 1997). Today, very few—if any—human chess players could outscore the best computer program over a series of games.

You know, of course, about handheld electronic games. Unless you are extremely skilled at chess, handheld chess-playing game can easily beat you. If chess-playing expertise is a measure of intelligence, such a computing device is very intelligent!

Of course, intelligence is far more than doing math or playing chess. Humans have the most versatile intelligent of any entity we know about. If the topic of AI interests you, you might want to read the free book Moursund (2006). Wikipedia (n.d.; Timeline) contains a nice timeline of developments in AI.

An Example of Increasing Computer Intelligence

For years, people have worked on developing voice input to computers and a means for the computer to process the input into language symbols. This is called the **speech to text** problem or the **speech recognition** problem (Wikipedia, n.d.; Speech).

I own speech recognition software. Right now, I want to use the software so you can see how well it works for me. As I start up the software, the computer tells me that there is a free update to the software. It takes less than a minute for my computer system to download and install the improved software. In some sense, this increases the speech to text “intelligence” of my computer.

The next paragraph was generated speech to text software on my Macintosh computer. I dictate using a microphone, and the computer hardware and software produces the text your see. My current computer is fast enough so that it handles voice input at my normal rate of talking. That is a lot faster than I can keyboard.

Hello. My name is Dave Moursund. I am talking to my computer.

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So far, so good. I am speaking quite distinctly today. Some days, my voice is sort of my she.

I am impressed by how well my computer is doing today. As I watched the text appear on the screen, I checked for errors. If I see an error, I can correct it.

Notice the end of the second paragraph. I said the word “mushy” and the computer heard this as “my she.” Remember, the computer has no understanding of what I am saying. It merely uses a sophisticated program to convert sound patterns into words.

The speech to text system learns when I make corrections. Thus, if I select the “my she” and key in the correction “mushy,” this will help the computer system to learn how to translate my pronunciation of “mushy” into the characters” mushy.”

Relative Strengths and Weaknesses

A computer brain/mind can do better than a human brain/mind in some areas and vice versa. For example, consider rote memory.

Have you ever tried to memorize a long poem? Some people are much better than others at such a task. With enough time and effort, an average person can memorize a whole book. However, there is a difference between memorizing a poem or a book, and understanding the possible meanings of the text.

The hard drive on my current computer can store about 450 gigabytes. One byte is a letter, digit, or punctuation mark. A medium-length novel is about a million bytes in length. My computer can “memorize” about 450,000 books. If that is too limiting for my work, I can add more disk storage. For example, less than \$500 buys enough disk storage to store another million books. An alternative is to merely use the Internet to connect to electronic libraries throughout the world.

The point is, when it comes to pure rote memory (storage and retrieval of data), computers are much better than people.

Another area where computer brain/minds exceed human brain/minds is quickly and accurately following algorithms and heuristics. You know, for example, that the Web is like a huge library that contains the equivalent of tens of millions of books. How long would it take you to look through all of this content and find every occurrence of my name? A Google search of “*Dave Moursund*” OR “*David Moursund*” takes about .2 seconds! Of course, not all of these hits are actually refer to me. It takes more than rote memory and rote retrieval to know if a hit actually refers to me.

The .2 seconds figure mentioned above is misleading. Search engines do a lot of indexing in advance of receiving search requests. Think of the idea of a search

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engine having a very large list of words that people might want to search on. During its “spare time,” the search engine looks up all of these words on the Web. It stores the Web address for each “hit.” It also stores some of the surrounding words, such as the sentence in which the word occurred. Thus, when you ask a search engine to find a word or several words, much of the search work has already been done. What remains to be done is finding hits that fit your request if your request has several words in it. Also, there is the task of ordering the hits from more important to less important. Quite a bit of the intelligence of a search engine lies in this ordering process.

Somewhat similarly, my computer can do more arithmetic calculations in one second than I could do in a lifetime of paper and pencil calculation. The point is, when it comes to pure rote following of an algorithm or heuristic that can be computerized, computers are much better than people.

However, as noted several times, computers do not “understand” in the sense that a person understands. What does it mean to be a human being? What does it mean to have consciousness? What are emotions? What is wisdom? Humans have a far deeper understanding of such questions and ideas than do the very best of AI systems.

These observations tell us something about what constitutes a good education. Learn to make use of a computer to do the things that you want done, and that computers can do much better than you. Develop your own expertise in areas where humans are much better than computers. Learn how to live a satisfying and responsible life in a world that has two kinds of brain/minds (Moursund, 2008).

The Turing Test

Alan Turing was a computer science pioneer. His work in breaking the Enigma code greatly contributed to the Allied victory in WWII. Among educated people today, he is most famous for what is now called the Turing Test for Artificial Intelligence.

In simple terms, the Turing Test involves a computer program carrying on a conversation with a human being through text messaging. The program’s task is to mimic a human. The human’s goal is to try to figure out whether he or she is communicating with a human or a computer.

Turing posed this test in 1950. Nowadays, there is an annual contest to select the best program that has been developed. There is a large cash prize for developing a program that consistently passes the Turing Test (Lobner, n.d.). The AI programmers are getting closer....

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Several computer programs available free on the Web can carry on a conversation. You may find it to be fun to try out some of these programs. For example, see Alicebot (n.d.) or jabberwasky.com (n.d.).

Writing: Computer and Human Brain Teamwork

Think about the overall problem of students learning to write and to communicate in writing.

Writing and reading were invented more than 5,000 years ago. The first schools were developed to teach writing and reading. There have been many changes over the past 5,000 years. For example, students no longer learn how to use a stylus to write on a tablet that they have molded out of clay and will later bake in an oven or dry in the sun. Students no longer learn how to select a quill and cut it to make a quill pen. Students now have pencils (with erasers), ballpoint pens, and paper.

Nowadays, many people write using a word processor. They compose at a computer keyboard. They use their minds, keyboarding skills, and writing skills. They also use the brain/mind power of a computer.

When I compose, the spell checker program compares every word to entries in the computer's dictionary and to entries in the supplemental dictionary I added. The program gets "smarter" at spell checking as I add words to my supplemental dictionary. The computer uses an algorithm to look up words, but uses heuristics—rules of thumb—to make suggest possible corrections to a word that it "thinks" is misspelled. Currently, the heuristics are sophisticated enough to provide a modest level of machine intelligence.

I frequently misspell certain words. My fingers often key *educatoin* when I mean *education*. I have taught my spell checker to automatically correct this spelling error. Thus, in some sense I have made my spelling checker more intelligent at meeting my personal needs.

My spelling checker also does grammar checking. It often detects possible errors in my grammar, and sometimes provides suggested corrections that seem correct to me. Grammar checkers have a certain level of grammar-checking intelligence. They have gotten better through many years of research, but they have a long way to go before they rival humans in this area.

When I am writing, I sometimes make use of a dictionary and thesaurus built into the word processor. These follow algorithms and are a good example of rote storage and retrieval of information.

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While I am writing, I make extensive use of the Web and a search engine. The search engine makes use of a number of heuristics to improve its performance (make it more intelligent). A number of researchers and programmers work steadily to improve the intelligence of the search engine.

My computer helps me write in other ways. For example, I have terrible handwriting. I keyboard much faster than I handwrite, and the results are legible. My computer system provides quite a bit of help in formatting my writing for desktop publication. In addition, it follows algorithms to carry out tasks such as page numbering, creation of a Table of Contents, and creation of an Index. (Of course, I tell it what items I want in the Table of Contents and Index.)

In summary, my computer and I form a writing team. Even though my word processor is not very smart (so I tell myself), it makes a major contribution to my writing.

Final Remarks

Here are some of the important ideas in this chapter:

1. Computers and computerized machines can do many things faster, more accurately, and cheaper than people.
2. People can do many things much better than computers and computerized machines.
3. In many situations, two brain/minds are better than one. "All of us are smarter than any one of us." (Attributed to the great baseball player Satchel Paige.)

The fact that you can read and understand this book means that you are making good progress toward achieving Stage 4 (formal operations) on Piaget's developmental scale. **Keep up the good work!**

Questions to Ponder

Each chapter in this book ends with a small list of questions to think about. Each provides an opportunity to learn more about a specific topic. Also, each provides an opportunity for you to learn more about your own thinking processes.

1. Name several things you can do better than a computer or computerized machine. Name several things that a computer or computerized machine can do better than you.
2. Think about a career you might like to have and judge you'll do well in. How will this career area be affected by continued progress in AI and other computer fields?

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3. Name and think about at least one thing in this chapter that you found interesting and relevant to your life.

Chapter 7: Games, Puzzles, and Simulations

“All the world’s a game,
And all the men and women merely players:
They have their exits and their entrances;
And each person in their time plays many parts, ...” (David
Moursund, 1936–; Adapted from Shakespeare.)

"The reason most kids don't like school is not that the work is too hard, but that it is utterly boring." (Seymour Papert, 1928–.)

Entertainment takes many different forms. People vary considerably in what they find entertaining. For example, I like to write books. It’s one of my forms of entertainment. I take pleasure in seeing a book emerge from my writing efforts. I feel good about making my books available free on the Web.

An essential goal of the entertainment industry is making money. Thus, it focuses on forms of entertainment that have large audiences. It produces “popular” television and movies, recorded music, games, toys, books, and so on.

ICT (Information and Communication Technology) has greatly changed the entertainment industry. Computer video games and simulations have become very popular. Some games are played individually, usually in completion with a computer program. Others are played in small groups facilitated by a computer. Still others have millions of players, all engaged in the same game.

Games can be designed to be educational. Edutainment games have a combination of educational and entertainment features.

Many people find computer games addictive! They find certain computer games to be so much fun to play that they have a hard time stopping. This type of addiction is a major challenge to many people. If you haven’t done so already you need to learn to take responsibility for how you use your time. A game-playing addiction can be devastating.

Introduction

This chapter draws heavily from the book:

Moursund, D.G. (2008). *Introduction to Using Games in Education: A Guide for Teachers and Parents*. Access at no cost in PDF and Microsoft word formats at: http://i-a-e.org/downloads/doc_download/19-introduction-to-using-games-in-education-a-guide-for-teachers-and-parents.html.

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Since my early childhood, I have enjoyed playing a wide variety of games. Indeed, at times I have had a reasonable level of addiction to various games. In retrospect, it is clear that I learned a great deal from the board games, card games, puzzles, and other types of games I played. I also learned that games can be addictive to me.

Oodles of games are now available in electronic format. Some electronic games are merely computerized versions of games that existed long before computers. Others only exist in a computer format. Computer networks have made possible games for many thousands of players. The computerized animation and interaction bring a new dimension to games.

Educational Ideas

Remember, your brain is learning all the time. When you are playing a game, your attention and learning tend to be focused on whatever the game is teaching, mentally or emotionally. This can help you get better at playing the game.

The next time you play a game, do some metacognition. Think about whether you are getting better at playing the game. Think about what you are learning. Think about whether this learning might transfer to other areas.

Also, think about how you are using your time. Perhaps there are better ways you could be using this game-playing time.

You likely know about some solitaire, one-player games. Klondike is a solitaire card game played using a deck of cards. It is widely played on computers. (Klondike, n.d.) It's one of the world's most widely played games. If you've played this game, think about what you've learned. How has this been useful (if it has) to you?

A multiplayer game facilitates interaction among the players. Many people play card games such as Hearts, Rummy and Bridge because of the social interaction they facilitate. When you think about what you learn by playing games, think about how they contribute to your social growth and what you learn about yourself and the other players.

When you first start to learn a new game, your expertise level is very low. Over time your expertise grows. A game that can set difficulty levels allows you to mark this growth. Through metacognition, you can see yourself learning and you can analyze how you are learning to learn.

I find it fun to compare and contrast schooling with learning to play games. For the most part, in school the teacher tells you what you have to learn. You gain

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expertise in areas that the teacher and other people think will be useful and important to you.

Some students make this situation into a type of game. They play the game to make the teacher or their parents happy, and to get by with minimal effort. In some sense, they rebel against the formal education system. Be honest with yourself. Have you ever done this? An alternative is to accept the advice and wisdom of adults until you reach a level of mental maturity and wisdom to be a good advisor to yourself.

Learning a game is usually part of informal education. You learn to play a computer game because you want to. If you don't get enough satisfaction out of the process, you merely stop learning the game and spend your time on something else.

It takes a great many hours of effort to develop a reasonable level of expertise in a game such as World of Warcraft. Consider this quote from Yasmin Kafai, a world leader in uses of games in education.

If someone were to write the intellectual history of childhood—the ideas, the practices, and the activities that engage the minds of children—it is evident that the chapter on the late 20th century in America would give a prominent place to the phenomenon of the video game. The number of hours spent in front of these screens could surely reach the hundreds of billions. And what is remarkable about this time spent is much more than just quantity. **Psychologists, sociologists, and parents are struck by a quality of engagement that stands in stark contrast to the half-bored watching of many television programs and the bored performance exhibited with school homework.** (Kafai, 2001). [Bold added for emphasis.]

In my opinion, this is a very profound insight into video games. And, video games keep getting “better” and better. That is, they keep getting more attention grabbing, attention holding, and addictive.

Edutainment

Many students find school to be fun. They enjoy the social interaction and the learning. Others find that school isn't much fun. Perhaps the social interaction is fun, but the learning “is a drag.” Perhaps the learning is fun, but the social interaction isn't.

If school is fun for you, you will have intrinsic motivation to attend and to learn. If school is not much fun for you, your motivation to attend may be mostly extrinsic. You attend because your parents and the school system require you to attend. The amount you learn will likely be much less than if you were intrinsically motivated. You may well drop out before graduating from high school.

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Many people have tried to combine the fun of games with the education they think students should be getting. The combination of games with teaching “school” subjects is called *edutainment*.

Some edutainment is highly successful. Suppose, for example, you want to become an airplane pilot. A standard approach is to receive formal instruction in a flight school. Flight schools make use of flight simulators. You can think of a flight simulator as a game. Indeed, there are many flight simulation games that one can play on a computer or various game machines.

A flight simulator immerses a student in a learning environment in which the students must use what has been learned and what is being learned. It is a learn-by-doing environment with good immediate feedback. It is a trial and error environment—but a crash does not kill the pilot trainee!

Training in a flight simulator is much less expensive and dangerous than training by flying a real plane. Of course, eventually the flight school education and training progresses to actual piloting a real plane.

Many forms of edutainment are not very good. For example, consider a typical “drill and practice” edutainment program. The learner is presented with a simple problem or question. A correct answer is “rewarded” by bells, whistles, and smiley faces.

These rewards are designed to help keep the student on task. However, these extrinsic rewards seem infantile compared to the intrinsic rewards of doing well in a flight simulator or in a challenging computer game.

Brain/mind Teaser Puzzles: Thinking Outside the Box

A puzzle is a problem or enigma mainly designed for entertainment. Often one can solve a puzzle without having to draw upon deep knowledge of any discipline. A jigsaw puzzle and a Rubric’s Cube provide good examples of this.

A person doing a jigsaw puzzle is engaged in tasks that involve looking for patterns, using spatial visualization skills. This puzzle playing may be done individually or in a small group. In the latter case, there is a strong social education aspect.

Other types of puzzles require a broad and deep background. For example, a crossword puzzle draws upon reading, spelling, word definitions, and obscure knowledge. Through study and practice, people can increase their crossword puzzle expertise. Many people get satisfaction in doing such puzzles.

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In some cases, there are 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's no longer a challenge. Here is a brain-teaser puzzle that requires thinking outside the box. As you explore this brain-teaser, think about your thinking and what might be learned by exploring this puzzle.

Problem: Using pencil and paper, arrange nine distinct dots into a three by three pattern as illustrated in Figure 7.1. 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.

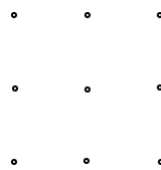


Figure 7.1. Nine dots in a 3x3 square pattern.

See if you can solve this puzzle before looking reading further.

To begin, you may think about how easy it is to complete the task using five line segments. A solution is given in Figure 7.2. After studying this solution, you can easily find other 5-line line segment solutions.

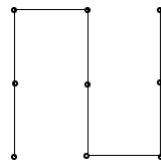


Figure 7.2. A 5-line segment solution for the 9-dots puzzle.

How can one possibly complete the task with only four line segments? It is necessary to think outside of the box. 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 7.3.

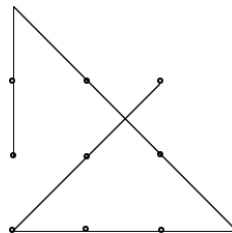


Figure 7.3. A 4-line segment solution for the 9-dots puzzle.

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

This is where a teacher enters the picture. A good teacher can help students discover personal examples of thinking outside the box. The teacher might be a parent, a schoolteacher, a sibling, or a peer. The point is, the teacher does a valuable service for the student. With proper instruction, most students can gain increased skill in making such connections by themselves. Clearly if you don't want to be boxed in, this is an important goal in education!

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 going on. Think outside the box!

This is a "trick" question. What is the difference between a mathematical point and a dot? 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 7.4.

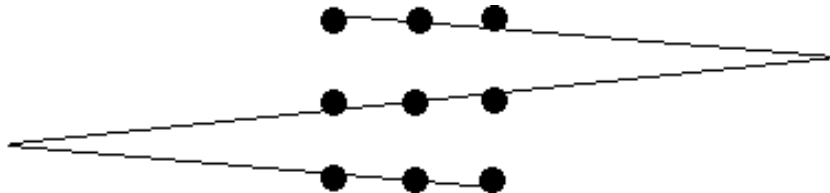


Figure 7.4. A 3-line segment solution for the 9-dots puzzle.

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 a challenge. When was the last time you solved a real-world problem by thinking outside the box? If you can't think of any example, then think about why you can't think of any examples. In either case, the next time you encounter a problem that you want to solve, explore thinking outside the box.

Here is a brain/mind teaser you can practice on:

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 rowboat, 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

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will eat the chicken. However, you know that Wolf does not eat grain. How do you get everything across the river and intact?

Here's a hint. When trying to move forward, sometimes it is necessary to spend some time moving backward. This is a useful strategy in many problem-solving situations. This is a good time to practice transfer of learning. Think of various situations in which you have used this back-tracking strategy.

The Web holds lots of brain/mind teasers. Use a search engine to search on *brain/mind teaser*.

Tic-Tac-Toe

You probably learned how to play Tic-Tac-Toe (TTT) many years ago. This section examines TTT to see some of the things that one might learn from the game.

TTT is a two-player competitive 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.

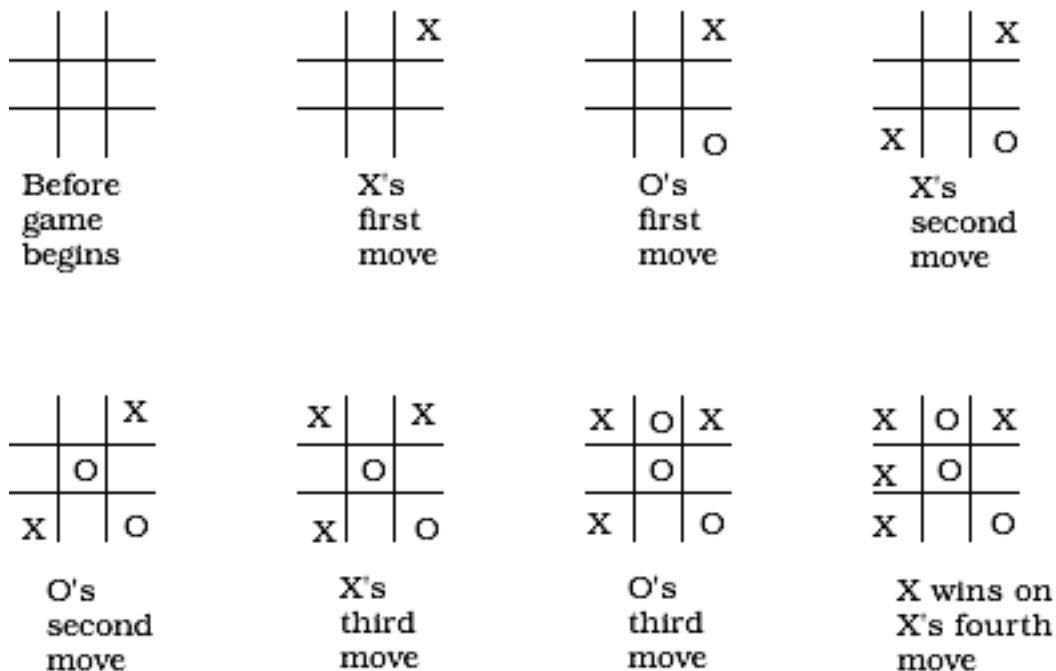


Figure 7.5. Example of a Tic-Tac-Toe game.

How Can a Computer Play TTT?

You know that computers can play some games quite well. Perhaps you believe that if a computer has been programmed to play a game, the computer will

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never lose. However, that is not the case. Let's use TTT for an example. Suppose that a computer has been programmed to make random moves when playing against a human opponent. When it is the computer's turn to make a move, it selects one of the legal available moves at random, and makes that move. As you might expect, a human player can often beat such a compute program.

You may enjoy creating a "by hand" simulation of this situation. Prepare nine small pieces of paper that are numbered 1, 2, ... 9, respectively, and place them in a small box. Number the spaces of a TTT board with the nine digits as follows:

1	2	3
4	5	6
7	8	9

Figure 7.6. A TTT board with its squares numbered 1 to 9.

Let us suppose, as an example, that X is going to play first and that X's moves will be randomly generated. You play O against the random mover. Start at step 1.

1. To generate X's move, stir up the pieces of paper in the box and draw one out. Its number will be the space in which X moves. Then one of the following 3 situations occurs:
 - 1a. If this move completes a file with three X's, X wins and the game ends.
 - 1b. Otherwise, if this is the ninth move in the game, the game ends and is a draw.
 - 1c. Otherwise, go to step 2.
2. You (O) make a move. If this produces a file with three O's, you win and the game ends. Otherwise, look into the box and remove the slip of paper that contains the number corresponding to the move you just made. Then go to step 1.

The set of steps can easily be written as a computer program. The set of steps is an algorithm that generates moves for X and determines who wins or if the game is a draw. It should be evident to you that just because a computer has been programmed to play a game, it does not follow that the computer wins all the time or will always play well. Indeed, the random number player will play poorly. However, it will occasionally best a child who is just learning to play the game.

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The idea of using random numbers in a computer program adds an unpredictability dimension to what a computer can or cannot do. People often argue about limitations of computers by stating that a computer can only do what it is told to do in a computer program. However, when this “telling the computer” includes making use of random numbers, the programmer or the program user may not be able to predict the results unerringly.

A TTT Algorithm That Never Loses

Next, we will explore a TTT algorithm that can be followed by a person or programmed into a computer, and that plays quite well. This algorithm is specifically designed to produce moves for X, who moves first.

Begin by numbering the nine squares on the grid as follows:

2	6	3
7	1	8
4	9	5

Figure 7.7. TTT board numbered to help specify a game-playing algorithm.

The first player (X) uses the following 4-part procedure to determine what move to make at each turn:

1. Examine the grid and carry out the following sub-steps:
 - 1a. If there are one or more files that contain 2 X's and no O's, play in the one that contains the lowest numbered blank space. Thus, X wins the game, and the game ends.
 - 1b. Otherwise, if there is only one blank square remaining, play in it. The game then ends as a draw.
 - 1c. Otherwise, go to step 2.
2. If there is a file containing 2 O's and no X, play in that file. Otherwise: go to step 3.
3. Consider each possible remaining legal move, from the lowest numbered one to the highest numbered one. For each, see if making that move would result in the creation of two or more distinct files

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each containing two X's and no O's. If (and as soon as) such a possible move is discovered, make it. Otherwise, go to step 4.

4. Move in the lowest numbered unused square.

Through some careful thought, you should be able to convince yourself that X (playing first) never loses. A key aspect of this set of directions is the “look ahead” strategy (consider each possible move) in step 3. This algorithm that never loses is dependent on X going first, on the board being numbered as shown, and on the “look ahead” feature in step 3.

Now, here is a writing challenge. After you “prove” to yourself that X will never lose, write your proof so that others can read it. A computer program is a step-by-step set of directions to a computer. A computer programmer writes a set of directions and tries to convince him or her self that there are no errors in the set of directions. It can be very difficult to “prove” that there are no errors in a computer program. Indeed, many people make a living just checking for possible errors in computer programs. Even then, complex programs such as an operating system contain errors. These errors can cause a computer to “crash.”

The Look Ahead Strategy

Use of the *look-ahead strategy* is a key feature in writing a program that plays a good game of chess, checkers, or other somewhat similar games.

On a more general note, “look ahead” is a process of considering the consequences of possible actions—before taking an action. Look ahead allows you to study possible outcomes of an action. This is important in computer game playing, but it is also an important and routine aspect of functioning as a responsible human being. Spend some time thinking about how often and how well you use the look-ahead strategy. For example, how important is “look ahead” when driving?

You might want to go back to Polya’s heuristic for problem solving. Notice the look ahead aspect of step 3. Remember the adage, “Look before you leap.”

Games Can Be Addictive

There are many different sources or types of addiction. Moreover, the term *addiction* is often used quite loosely. Thus, an observer might say that I am addicted to my morning cup of coffee. This observer might then go on to talk about caffeine being an addictive drug and that people experience headaches and other effects as they try to kick the caffeine habit.

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Games can be addictive. When I was in graduate school, one of my friends was addicted to solitaire card games. This caused him to flunk out of graduate school.

Some types of solitaire games are very mentally challenging, requiring deep concentration and careful thinking. The “thrill of victory and agony of defeat” is experienced repeatedly in such games. The immediate mental stimulation can be exhilarating. My friend found that such immediately available rewards overwhelmed the feelings of satisfaction gained through being a physics student.

Deep thinking, concentration, and immersion can occur in many settings. Personally, I find that deep engagement in computer programming or in developing a spreadsheet has the same characteristics as game playing. For me, games, computer programming, spreadsheets, and writing are all environments in which I can immerse myself.

In these settings, I find deep satisfaction in using my creativity and brain/mind power. I experience what Mihaly Csikszentmihalyi calls *flow*. Mihaly Csikszentmihalyi is a world expert and leader in Flow Theory. Quoting from Csikszentmihalyi (n.d.):

Mr. Csikszentmihalyi (pronounced chick-sent-me-high-ee) is chiefly renowned as the architect of the notion of flow in creativity; people enter a flow state when they are fully absorbed in activity during which they lose their sense of time and have feelings of great satisfaction. Mr. Csikszentmihalyi describes flow as "being completely involved in an activity for its own sake. The ego falls away. Time flies. Every action, movement, and thought follows inevitably from the previous one, like playing jazz. Your whole being is involved, and you're using your skills to the utmost."

I have found Csikszentmihalyi's writings about flow to be quite interesting. Many people have decided that flow is a desirable state. Indeed, one might say that many people have become addicted to flow. This may be an example of a good addiction.

Here are two ideas that occurred to me as I was writing this section:

1. All children growing up in our world will encounter numerous addictive or addictive-like drugs, opportunities, and situations. Part of a good education is to learn about how to deal with these situations. For some people, games are sufficiently addictive-like, that they provide an opportunity to study themselves in an additive-like setting.
2. For many students, games are intrinsically motivating. Motivation—or the lack thereof—is a very important aspect of

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education. Teachers work hard to motivate their students; parents work hard to motivate their children. How can teachers and parents take advantage of the intrinsic motivation of games? Undoubtedly you have heard the adage, “If you can’t beat them, join them.” Outside the box thinking suggests that games be integrated into the ordinary, everyday school curriculum. Our informal and formal educational system should learn to take advantage of the addictive-like qualities of games.

Final Remarks

Here are some of the important ideas in this chapter:

1. Games, puzzles, and simulations can be useful in education.
2. Game players learn strategies such as planning ahead and considering possible consequences of planned moves. Many of the strategies used in game playing are applicable in attempting to solving problems outside of gaming.
3. Good quality edutainment combines good quality education with intrinsically motivating and challenging games. Most current edutainment software fails to achieve this goal.
4. Game playing can be addictive. Learn to take responsibility for how much time you spend playing games. Learn about yourself as you study your game-learning and game-playing behaviors.

Questions to Ponder

Each chapter in this book ends with a small list of questions to think about. Each provides an opportunity to learn more about a specific topic. Also, each provides an opportunity for you to learn more about your own thinking processes.

1. Make a list of your main forms of entertainment. Estimate how much time you spend per week on each of these. Are you satisfied with how you are spending your entertainment time?
2. If you play computer games, think about your favorite game or games. Why are they your favorites? What do you learn by playing these games?
3. Name and think about at least one thing in this chapter that you found interesting and relevant to your life.

Chapter 8: The End of the Beginning

"Today is the first day of the rest of your life." Abbie Hoffman, 1936–1989.)

Education is what survives when what has been learned has been forgotten." (B. F. Skinner, 1904–1990; psychologist, inventor, and author.)

As with other chapters, be sure you read the quotations at the beginning of the chapter. You're nearing the end of this book. The rest of your life is just beginning.

This chapter discusses a variety of topics, each worthy of a whole chapter—but a book has to end sometime. If a topic seems interesting to you, take it on yourself to learn more. Take responsibility for your own education and future!

Introduction

Every book tells a story. Some stories take few words. The reader fills in details. Other stories are long and detailed. They involve many different subplots woven together to tell a long story. Textbooks have this characteristic. Each chapter is a story within itself. The chapters together tell a larger story.

Quotations

Each quotation at the beginning of this book's chapters can be thought of as a very short story. The Appendix to this book contains the quotations used at the beginning of the chapters. It also contains a few of my other favorites such as the following pair:

"Knowledge is power." (Sir Francis Bacon, 1561-1626)

"With great power comes great responsibility." (Stan Lee: Uncle Ben, talking to Peter Parker in Spiderman movie.)

I'm not as good as I'd like to be at memorizing quotations. Realizing that, I write down those I might want to use some day.

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

Videos

Nowadays, many people tell their stories using video. Here is a two-minute video I think you will enjoy. And, it will likely broaden your faith in the people of our world.

Becoming More Responsible for Your Education

In celebration of India's 60th year of independence, the Times of India launched an initiative to inspire the search for hidden talents in everyday people. Among the results is this two-minute video. <http://www.karmatube.org/videos.php?id=299>.

Some of the best educational videos I've ever seen are only about 18 minutes in length. See <http://www.ted.com/talks>.

TED stands for **Technology, Entertainment, Design**. It started out (in 1984) as a conference bringing together people from those three worlds. Since then its scope has become ever broader.

The annual conference now brings together the world's most fascinating thinkers and doers, who are challenged to give the talk of their lives (in 18 minutes).

These videos are intended mainly for people with an adult level of mental maturity. Try out several of these videos. If they don't seem to "click" with you, come back in a year or two and try again.

Writing This Book

When I start out to write a book, I make an estimate of how long the book needs to be. How many pages will it take to tell the story? I like to keep my books relatively short. Can I say what I want to say in less than a hundred pages? Why can't I say it in a ten page article? Indeed, why can't I say it in one page? After all, today's television ads are often 15 seconds or 30 seconds in length.

The cover page of this book includes a start on a two-page version of the book.. It is too short to tell the story. The reader is left with too few details. Most readers cannot fill in the missing pieces.

On the other end of the scale, few students will read a long scholarly book just for fun. Thus, I decided that this book should be well under a hundred pages in length. Think about scoring in golf. A lower score is better. In this book, I did manage to score under 100 (pages).

I then made a list of topics that I might cover in the book. I worked on grouping like topics and arranging the groups in a "logical" order. In essence, I developed a very rough draft outline for the book.

Next, I began sorting out what I thought was really important from what seemed less important. This left me with a rough outline and a bunch of leftovers.

When I'm writing, I respect the leftovers, rough drafts, and pieces that just don't seem to be coming out right. I save all of them at the end of the document. Thus, a 100- page book often grows into a 200-page document. From time to time I look at the leftovers to see if some should be salvaged, revised, and used in the book.

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This current book grew into a document of more than 200 pages. As I neared the end of writing about the topics that seemed most important, I saw there were many other topics that could have been included.

This final chapter is my compromise: A collection of bits and pieces I think belong in the book. Indeed, many of these could be expanded into complete chapters. However, the first seven chapters tell enough of the story. You can fill in the details. You can practice on topics given here in the 8th chapter and see if they interest you. For the ones that interest you, you can take responsibility for learning about them on your own.

Your Total Expertise Portfolio

As noted early in this book, nature has given you many gifts. You've built on these gifts to develop various levels of expertise in various areas.

Think about making a list of your areas and levels of expertise. You don't need to compare yourself against anyone. Instead, begin by thinking about what you are best at. Give yourself an expertise level of 5 for this area.

Next, think about some other areas that you or others think are important to you. Select one where you have a low level of expertise. Give yourself an expertise level of 1 for this area.

Just for the fun of it, add a 6 and 7 to your scale. Eventually you will need to use those scale points as your expertise levels grow.

You now have a personal expertise scale that runs from 1 (low) to 5 (high) and on to 7 (extra extra high). As you continue with rating your levels of expertise in different areas, you will soon produce examples for the in-between points on your scale. You don't need to think of every possible area in which you have expertise. Just make sure you include a number of the areas that you, your parents, your schools, and so on feel are important.

When you're done listing and rating areas of expertise, you'll have produced your Total Expertise Portfolio. You can spend time thinking about what areas in which you want to increase your expertise. You can develop plans for how to increase your expertise in these areas. You can take responsibility for implementing these plans.

Here is a useful idea. Every few months, look at your Total Expertise Portfolio. Revise it, select some new goals, and develop some new plans.

The idea of a Total Expertise Portfolio isn't new. Joseph Renzulli calls it a Total Talent Portfolio. Renzulli is a world-class educator who has specialized in talented and gifted (TAG) education. His ideas are applicable to all students. You

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can learn more about both Renzulli and TAG in Moursund (2006). Quoting from Renzulli (1998):

Students should achieve autonomy and ownership of the TTP [Total Talent Portfolio] by assuming major responsibility in the selection of items to be included, maintaining and regularly updating the portfolio, and setting personal goals by making decisions about items that they would like to include in the portfolio. Although the teacher should serve as a guide in the portfolio review process, the ultimate goal is to create autonomy in students by turning control for the management of the portfolio over to them.

Education for Expertise

Here's one way to describe a good education: A good education helps you to know a little about a lot of things and a lot about a few things. The goal is gain a personally satisfying level of expertise in many areas and a much deep level of expertise in a few areas.

Here's one way to think about this idea. If you want something done, you can do it yourself or you can get others to help you. It takes a certain amount of expertise and time to do something yourself. If you have money and/or are persuasive, you can get others to do things for you or to help you.

Most people find they want to do some things for themselves, and they want to have the resources to have others do some things for them. What this suggests is:

1. Gain expertise so you can do the things you want to do (without pay) for yourself and for others. This means gain some expertise in lots of different areas. Become a Jack or Jill of many trades.
2. Gain the expertise to make money so you can have other people do some things for you. This means gain depth of expertise in one or more areas so that you can efficiently make money.

Earning Money

In some areas, you can gain an income-producing level of expertise in a short time. For example, when I was in high school, I worked in a large bakery for part of a summer. I filled in for people on vacation. I did several easy-to-learn jobs. Training took only a few minutes. The pay was great (for a high school student). The satisfaction came mainly from the money I earned.

While I was in junior high and high school, I also did other types of work. I did general lawn and garden work. I did some house painting. I did some tutoring in math. I did baby sitting.

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These types of work were more personally satisfying than my bakery work. However, all of these jobs paid less than the bakery. Eventually, after four years of college and four years of graduate school, I became a university faculty member. The pay was all right and the level of personal satisfaction was high.

My conclusion is that it tends to be intrinsically rewarding to develop a high level of expertise in an area and then regularly make use of this expertise. In my job as a professor, I got to keep learning all of the time. I got to use my steadily increasing knowledge and expertise. I got to do things that contributed to making the world a better place.

I knew that lots of people with far less education earned more money. However, I achieved a good balance—for me, personally—between having a satisfying career and earning enough money to meet my needs.

Self Assessment

The Total Expertise Portfolio is based on self-assessment. You are not asked to compare yourself to others. You are asked to make rough, personal comparisons.

Self-assessment can be done more precisely in many areas. Here's an example. When you read a page in this book, how fast do you read and how well do you learn from what you read? It's easy to calculate your reading rate. In addition, a number of Websites provide a reading rate and reading understanding test. (See how good you are at finding some of these.)

What's your resting pulse rate? What's your blood pressure? What's your resting respiration rate? What's your reaction time? How well do you see? Do you have some color blindness? How healthy are you? How long does it take you to run a hundred meters? How long does it take you to swim 50 meters? How high can you high jump? How long does it take you to memorize a sequence of 10 random digits?

You probably detect a pattern in these questions. It is possible to measure many things about yourself. Some of these things can be changed by diet and exercise. Some can be changed training and education. For things that you cannot change (such as color blindness), you can learn to accommodate.

In all cases, you can think about whether your performance meets your own needs. In some areas, you can learn how your performance compares with others.

Graduating from High School

You have the brain/mind power to be successful in high school. Indeed, if you can read and understand this book, you have the brain/mind power to succeed in college. I have no idea whether you are currently meeting your mental potentials.

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Here is some information that suggests many students are not. Quoting from Wise (2008):

There is clearly a crisis in U.S. high schools. Nationally, barely 30 percent of [9th grade] freshmen can read at grade level. More than 1.2 million U.S. high school students drop out every year—roughly 7,000 each school day. Forty-two percent of freshmen in community colleges and 20 percent of freshmen in public four-year institutions require remedial courses in reading, writing, or math to handle college-level work. In survey after survey, employers express disappointment in the skills of high school graduates.

There are lots and lots of reasons why students drop out of school. Seldom is it because they are not smart enough to learn the material and pass the courses. One of the reasons for dropping out is not understanding or caring about the long-term consequences. Here is a quote from O*NET (n.d.):

The Bureau of Labor Statistics, a branch of the U.S. Department of Labor, classifies civilian occupations into a series of five “job zones.” Part of the Occupational Information Network, or O*NET, database, those categories are defined on the basis of the preparation such work typically requires along three dimensions—education, experience, and training. The lowest levels, Job Zones 1 and 2, are filled by occupations that call for a high school diploma or less, and little training or experience. Zone 3 jobs, by comparison, usually require substantial vocational training, work-related experience, or formal education beyond high school, although not necessarily a postsecondary degree. A four-year college degree is typically the minimum requirement for entry into Zone 4 and 5 occupations.

Distance Education

You learn from two major sources of data and information:

1. Data and information that you take in through your senses. Your brain automatically filters out most of this what your senses sense. However, some of it passes on into the parts of your brain that can analyze the information. Your brain seeks meaning from the information. It integrates this meaning in with the understanding and meaning you have accumulated in the past.
2. Much of your learning comes from analysis and reanalysis of what you have already learned. You think about (reflect on) data, information, knowledge, and wisdom stored in your brain. Through this process you learn new things and strengthen your learning of things you have learned in the past.

Distance education is a term used to describe use of computer, the Internet, the Web, telephone, television, radio, recordings, books, and so on to bring

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information from outside your body to your senses. When you look up” some information on the web, you are engaged in distance education.

In some parts of the United States, it is now possible to do an entire precollege program of study over the Internet. Indeed, college degrees can be taken via such distance education.

What is (Name Any Discipline) and Why Do I Need to Learn It?

This “What is...” question can be asked for any discipline. You’ll find it useful to know short answers for many disciplines. For the disciplines you study in school, an answer provides a foundation for future learning. For other disciplines, the knowledge will help you decide whether you might want to learn more about the discipline. You can only plan for a specific career if you know the career exists.

Why do you think students are required to study some disciplines in school? For example, consider reading, writing, and math. Why are these core subject areas that all students are expected to study? (Indeed, in many states, students must pass state tests in these areas in order to graduate from high school.)

Such required coursework reflects the collected wisdom of many adults. But, what do they really want you to learn? Why do they want you to learn this?

In some disciplines, it’s easy to give an answer. Reading is very important in our society. Reading is used to access information. It’s quite difficult to be a self-sufficient responsible adult if you cannot read. Moreover, it’s possible to measure how well a person can read.

Writing is an aid to organizing and communicating your thoughts. Reading and writing together help overcome a number of limitations of your brain/mind.

How about arithmetic and “higher” math? First, consider numbers (quantity), counting, and the low-level arithmetic that’s part of everyday life. This includes being able to do mental estimates and simple calculations in your head. Such numeracy can be thought of as part of the reading and writing literacy. It is important in being a self-sufficient responsible adult.

Just for the fun of it, let’s look a little more deeply into math. Besides quantity, counting, and simple arithmetic, what is math? Why are students required to take math year after year? Why are many states now requiring students to pass a state algebra test in order to graduate from high school?

This question is not so easy to answer. One of my hobbies is asking adults if they ever make use of the algebra they studied in secondary school. You can try the same question on adults you know. Of course, you will use “higher” math in

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the math courses you are required to take in high school. And, you will probably use some of this math in the required high school science courses.

But how about outside of school? If this topic interests you, will likely enjoy the Folk Math article by Gene Maier, available at http://iae-pedia.org/Folk_Math.

Here are three types of good answers as to why higher math is required of all students:

- Many careers require it.
- Higher math has a strong emphasis on a type of careful, logical reasoning that is important in many disciplines.
- Translating problems into math problems, and then drawing on the world's huge accumulated knowledge can solve many problems. (Indeed, computers can solve many of these problems.)

To find more answers to the “What is math?” question, see http://iae-pedia.org/Math_Education. If you want to learn more about what I think students should be learning about math, see my free (short) book:

Moursund, D.G. (June 2006). Computational Thinking and Math Maturity: Improving Math Education in K-8 Schools. Access at <http://uoregon.edu/~moursund/Books/ElMath/ElMath.html>.

Build Your Own Library—A Digital Filing Cabinet

The first libraries were developed about 5,000 years ago. This was shortly after the first written language was invented. For a nice summary of the history of the library, see Krasaner-Khait (2001).

The Web is a very large, “virtual” library. It contains millions of free books, journal articles, photographs, maps, recordings, videos, computer programs, and electronic games. It also contains lots of material that is not free.

Some of the Web material is Open Source—available for you to use and share with others (Open Source, n.d.). The book you are currently reading is an example of the rapidly growing collection of professional-quality materials available free on the Web.

The Web is so large that it is often overwhelming. I use a search engine and I give it some search terms. The search engine tells me it has found about 500,000 “hits” and lists the first few. Different search engines give different results.

I don't know which, if any, of the hits will satisfy my needs. Do they provide accurate, up to date, unbiased information? Often I need to look at a number of my hits to find the information I need. Indeed, often I need to refine my search to

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produce hits that are more useful to me. If I am reading about a topic that I don't know much about, I find it hard to decide on what to read first. Personally, I find the Wikipedia quite useful in getting started on a new topic.

This situation is quite a change from using the small personal library you probably have at home. Your personal library contains materials you have used and may want to use again. Probably your collection is small enough so you can easily look it over to refresh your mind on what's available. The materials are familiar to you.

This is far different than the impersonal, huge collections of material in large libraries and on the Web. One challenge you face if you want to be part of the educated class is learning to use the Web and other large libraries to meet your personal needs. When you need some particular information, you want to be able to find it quickly. You want what you find to be accurate and up to date, and to fit your needs.

Here are three ideas:

1. View each time you use the Web as an opportunity to help maintain and increase your level of Web-use expertise. Set a personal goal of becoming a high-level Web-using expert.
2. Learned to use several different search engines, and learn to use the Advanced Search features for several different search engines.
3. Build a personal collection of electronic documents and links to Web sites that fit your needs. This list might include brief descriptions of the sites, or you might keep the descriptions in your head.

I call the results of doing (3) a Digital Filing Cabinet (DFC) . Some of my DFC is personal—not for sharing. I store my games and financial records on my personal computer.

However, I also maintain a public DFC. That is, I have a Website where I store materials that I want to share with others, and that I can legally share with others. See: <http://iad-pedia.org>. This particular Website is a Wiki, and other people can contribute to it.

Your personal library can contain both links to material and actual copies of material. Thus, for example computer games that you own can be in a Games folder in your computer. If you like, you can download the book you are now reading and keep a copy in an Educational Materials folder. For more ideas on creating your personal electronic library see:

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- http://iae-pedia.org/Digital_Filing_Cabinet/Overview
- http://iae-pedia.org/Main_Page_-_Open_Access_Libraries.2C_Databases.2C_Software.2C_Textbooks

Health, Life Expectancy, and the Aging Brain

As you plan your education and your future, it might be helpful to have an estimate of how long you are apt to live. Your life expectancy is determined by a combination of nature and nurture. Eat right, exercise, don't smoke, don't be an alcoholic, wear a seatbelt when riding in a car, and so on—and you are apt to live much longer.

Life expectancy estimates are statistical. Thus, they cannot tell you if you will be involved in a fatal accident or contract a fatal disease next week, next month, or next year. Instead, such forecasts take into consideration the probability of such an occurrence.

Here are two sites that I have enjoyed using:

- Life Expectancy: http://www.nmfn.com/tn/learnctr--lifeevents--longevity_game The Longevity Game. Very simple and short. Easy to try experiments of the “What if ...?” variety.
- Living to 100: <http://www.livingto100.com/> Quite an extensive list of questions. Asks for some personal information (email address) that you may not want to provide. My suggestion is that you provide a factitious address if you do not want them to contact you. Provides good feedback and suggestions.

These sites ask for information about height and weight, in order to calculate your basic mass index (BMI). There are many no-hassle sites that are easy to use to calculate just your BMI. For example, see the National Institute of Health: <http://www.nhlbisupport.com/bmi/>.

You may have noticed that as people get quite old, they have trouble remembering names of people and things. There is a lot of research currently going on about the aging brain. Much of this is quite optimistic. Here is an example of such optimistic findings:

Reistad-Long, Sara (5/20/08). Older brain really may be a wiser brain. NT Times Research. Retrieved 5/21/08:
<http://www.nytimes.com/2008/05/20/health/research/20brai.html?em&ex=1211515200&en=6b45984e523a9f97&ei=5087%0A>.

Quoting from the article:

When older people can no longer remember names at a cocktail party, they tend to think that their brain power is declining. But a growing number of studies suggest that this assumption is often wrong. Instead, the research finds, the aging brain is

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simply taking in more data and trying to sift through a clutter of information, often to its long-term benefit.

In recent years, research has provided us with considerable evidence of the effects of physical exercise on the brain/mind. See:

Yelamanchili, Venkat (8/11/07). Exercise helps sustain mental activity as we age Retrieved 5/21/08:

http://www.rxpgnews.com/dementia/Exercise_helps_sustain_mental_activity_as_w_e_age_4823_4823.shtml.

Quoting from this article:

Based on a review of studies on exercise and its effect on brain functioning in human and animal populations, researchers find that physical exercise may slow aging's effects and help people maintain cognitive abilities well into older age. . . . Furthermore, fitness training—an increased level of exercise—may improve some mental processes even more than moderate activity, say the authors of the review.

Higher education appears to have long-term cognitive health benefits. See:

ScienceDaily (4/10/05). Brain imaging suggests how higher education helps to buffer older adults from cognitive decline. Retrieved 5/21/08:

<http://www.sciencedaily.com/releases/2005/03/050326011643.htm>.

Quoting from the article:

A new study from the University of Toronto sheds light on why higher education seems to buffer people from cognitive declines as they age. Brain imaging showed that in older adults taking memory tests, more years of education were associated with more active frontal lobes—the opposite of what happened in young adults. It appears possible that education strengthens the ability to “call in the reserves” of mental prowess found in that part of the brain/mind.

“Use it or lose it” is now a generally accepted statement about cognitive capability.

From time to time you may have questions about health issues. The Web is a great resource. Here are some resources that you will likely find helpful:

- WebMD. See <http://www.webmd.com/>.
- Powell, Don R. and the AIPM (2006). Students' self-care guide. *American Institute for Preventive Medicine*. Retrieved 4/29/07:
<http://healthcenter.uoregon.edu/patientinfo/handbook/index.htm>.
- Mayo Clinic. <http://www.mayoclinic.com/>

Communicating in Writing

Probably you can handwrite and print well enough so others can decipher what you write. Indeed, you may have spent a lot of time on your handwriting.

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However, good handwriting is of decreasing importance. Nowadays, well over two-thirds of students taking college entrance exams print the essay part. Many would keyboard their response if they were allowed to.

However, writing using a word processor brings with it some new learning requirements. Of course, you need to learn to use a word processor. A reasonable amount of keyboarding expertise is highly desirable. But, you are also faced by the problem of what typefaces and sizes to use. You need to know about typography. You need to deal with the fact that your pages can contain graphs, charts, tables, and pictures. Your writing can also contain links. If you are writing on the Web, your writing can be interactive and include audio and video.

Another interesting consideration is the level at which you write. You want to write so that people can read and understand what you are writing. Besides what your word processor offers, the Web has sites where you can check the readability level of the materials you write.

- Text readability: <http://www.storytoolz.com/readability/index>.
- Text readability (Simple Measure of Gobbledgook): <http://www.wordscout.info/hw/smog.jsp>.
- Website readability: <http://juicystudio.com/services/readability.php#readweb>. Enter a Website address and the program will go to that site and analyze the text in the document.

Computer Ethics

I assume that you set high ethical and moral standards for yourself and expect them of others. Ethics is the study of moral standards, and morality is:

1. standards of conduct that are accepted as right or proper
2. the rightness or wrongness of something as judged by accepted moral standards (Encarta® World English Dictionary © 1999 Microsoft Corporation)

Computers have brought a new challenge to all of us. It is now very easy to make and share electronic digital copies of intellectual property belonging to others.

Quoting from the Wikipedia:

In law, intellectual property (IP) is an umbrella term for various legal entitlements which attach to certain names, written and recorded media, and inventions. The holders of these legal entitlements are generally entitled to exercise various exclusive rights in relation to the subject matter of the IP. The term intellectual

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property reflects the idea that this subject matter is the product of the mind or the intellect, though the term is a matter of some controversy.

Computer ethics deals with how computer-using people make decisions about their uses of Information and Communication Technology (ICT). Gradually, governments are developing laws that help to define and legal systems are working to uphold ICT “standards of conduct that are accepted as right or proper.” Right now, many people ignore the laws and/or seek and find loopholes. For example, you undoubtedly receive quite a bit of email spam. Our laws and legal enforcement system have not succeeded in dealing with the spam.

A number of people and organizations have developed computer ethical standards. Many of the materials currently in use are rooted in the “Ten Commandments of Computer Ethics” that first appeared in an article written by Ramon C. Barquin (1992) and published by the Computer Ethics Institute.

On the Lighter Side

The Web provides lots of entertainment. For example, if you like jokes, there are lots of joke sites. Just do a Web search on jokes. If you like short entertaining videos, lots of these are available. Here are some I’ve enjoyed recently.

- http://nsfgov.httpsvc.vitalstreamcdn.com/nsfgov_vitalstream_com/mentos_coke.swf
- <http://www.youtube.com/watch?v=RuuesBhOR9g>
- <http://www.youtube.com/watch?v=W1czBcnX1Ww>

Final Remarks

Each person—even an identical twin—is unique. Nature has given you a unique set of potentials. Nurture has helped you to develop these potentials. Your Total Expertise Portfolio (see earlier in this chapter) can be used to assess your personal results.

Throughout your life, you will face trying to meet your own needs and wants, and trying to meet needs and wants of others. Your life will be full of problem situations. Many you will deal with at a subconscious level. However, many will require careful thought and drawing on your resources.

Through study, mental and physical exercise, and practice, you can build your mental and physical resources. You can also become more skilled at deciding how to use your resources. You can learn patience. You can learn to delay your hunger for immediate gratification to reap greater rewards later.

I hope that you have benefited by reading this book. If it has, please tell your friends about this free resource.

Questions to Ponder

Each chapter in this book ends with a small list of questions to think about. Each provides an opportunity to learn more about a specific topic. Also, each provides an opportunity for you to learn more about your own thinking processes.

1. What topic or topics do you think should be added to this book? Send email to the author, <mailto:moursund@uoregon.edu> naming one or more topics that you feel should be added. And, of course, explain why you feel they should be added.
2. Name and think about at least one thing in this chapter that you found interesting and relevant to your life.
3. Name and think about two or three things in this book that you found interesting and relevant to your life.

Appendix: “Pithy” Quotations

"Nothing gives an author so much pleasure as to find his works respectfully quoted by other learned authors."
(Benjamin Franklin)

“Cash is the sincerest form of flattery” Lazarus Long

There are one or more quotations at the start of each chapter. I think that is a fun way to “jazz up” a book. Some people make use of their favorite quotations in the signature block of their email messages.

Over the years I’ve put together a large collection of quotations I enjoy. You can access my list at <http://uoregon.edu/~moursund/dave/quotations.htm>.

Given below are all of the chapter-starting quotations used in this book, plus a few extra that I thought about using. They are in alphabetical order, by authors.

“Always thoroughly check out a gift horse.” (Anonymous.)

“After forty years of intensive research on school learning in the United States as well as abroad, my conclusion is: What any person in the world can learn, almost all persons can learn if provided with appropriate prior and current conditions of learning.” (Benjamin Bloom. *Developing Talent in Young People*, 1985.)

"Knowledge is power." (Sir Francis Bacon, 1561-1626)

"In short, learning is the process by which novices become experts. " (John T. Bruer; president of the James S. McDonnell Foundation.

“The longest journey begins with the first step.” (Ancient Chinese proverb.)

"Before you become too entranced with gorgeous gadgets and mesmerizing video displays, let me remind you that information is not knowledge, knowledge is not wisdom, and wisdom is not foresight. Each grows out of the other, and we need them all." (Arthur C. Clark; 1917–2008.)

"Learning without thought is labor lost." (Confucius, 551-479 B.C.)

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

"Adults are obsolete children." (Theodor Seuss Geise, AKA Dr. Seuss; 1904–1991.)

"Try to learn something about everything and everything about something."
(Thomas H. Huxley; 1825–1895.)

Don't worry about what anybody else is going to do. ... The best way to predict the future is to invent it. (Alan Kay; 1940–.)

"All progress is precarious, and the solution of one problem brings us face to face with another problem." (Martin Luther King Jr.; 1929-1968.)

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"With great power comes great responsibility." (Stan Lee: Uncle Ben, talking to Peter Parker in Spiderman movie.)

"If I had eight hours to chop down a tree, I'd spend six sharpening my axe."
(Abraham Lincoln; 1809–1865.)

"All the world's a game,
And all the men and women merely players:
They have their exits and their entrances;
And each person in their time plays many parts, ..." (David Moursund; 1936–,
Adapted from Shakespeare.)

If I have seen further it is by standing on the shoulders of giants. (Isaac Newton, English mathematician & physicist, 1642–1727. Letter to Robert Hooke, February 5, 1675.)

"Rule No. 1: Use your own good judgment in all situations. There will be no additional rules." (Bruce, Jim, and John Nordstrom, co-presidents of Nordstrom department stores, in the employee handbook.)

"You can lead a horse to water, but you can't make it drink." (Ole adage.)

"Age is a case of mind over matter. If you don't mind, it don't matter." (Satchel Paige, Baseball Hall of Famer, 1906–1982.)

"The reason most kids don't like school is not that the work is too hard, but that it is utterly boring." (Seymour Papert; 1928–.)

"Fortune favors the prepared mind." (Louis Pasteur; 1822–1895.)

"Once you have learned how to ask relevant and appropriate questions, you have learned how to learn and no one can keep you from learning whatever you want or need to know." (Neil Postman and Charles Weingartner. *Teaching as a Subversive Activity*, 1969.)

"The wisest mind has something yet to learn." (George Santayana; 1863–1952.)

"The real problem is not whether machines think but whether people do." (B.F. Skinner, 1904–1990; *Contingencies of Reinforcement*, 1969.)

Education is what survives when what has been learned has been forgotten." (B. F. Skinner, 1904–1990; psychologist, inventor, and author.)

"The most difficult thing in life is to know yourself." (Thales; 642BC-546BC, Greek philosopher.)

"The illiterate of the 21st century will not be the one who can not read and write, but the one who can not learn, unlearn, and relearn." (Alvin Toffler; 1928–.)

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

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