Chapter 9

Miscellaneous Other Topics

If life doesn't offer a game worth playing, then invent a new one. (Anthony J. D'Angelo; Founder of The Collegiate EmPowerment Company and creator of The Inspiration Book Series)

This is a collection of topics that were identified as being relevant and important to the themes of the book, but that are not included in previous chapters. My goal was to have this book be relatively short. Therefore, I decided to lump all of these topics together into a final chapter. One way to think about this chapter is that it consists of a large number of mini-chapters. Alternatively, think of this chapter as a future writing challenge to the author. Each section of this chapter could be developed into a complete chapter.

When I write a book on a particular topic, I spend a lot of time reading and talking to people about the topic. Eventually, I begin to get an idea for the topics I want to include in the book. As I work on organizing the topics, I continue to search for other possible topics.

I know that I have a good organization for the book when each new topic that I find fits into the general structure that I have developed. For this book on games in education, I continued to find topics that did not fit very well. So (much like I do when I am playing some games against a computer), I have decided to cheat. This chapter contains several very important topics that do not fit well into the general outline provided by the first eight chapters. I have lumped them and some other topics under the title Miscellaneous.

Women and Gaming

Women and gaming is a huge topic. A recent Google search of women and computer games produced over 100 million hits. For a “typical” overview (non research) article, see:


Quoting from the article:

Right now, a number of attempts are being made, in both Britain and America, to integrate computer games into the fabric of secondary education. In the USA, where such efforts are particularly advanced, there are fears that the size of Lara Croft's breasts will not just put girls off computer games, but off IT as a discipline. Henry Jenkins, director of comparative media studies at the Massachusetts Institute of Technology, argues that, being the first introduction girls have to computers, sexist computer games are partially responsible for the gender gap in the whole of US computer science.

For a fairly recent book on women and computer games see:


Sheri Graner Ray gives the reader an overview of what she sees as some of the central game design issues developers need to take into account if they want to really tap into a larger, more diverse market for their products. She suggests that there is a latent female audience basically waiting for developers to wise up and start providing a wider range of titles that cater to a variety of tastes. One of the best things about this book is the way Graner Ray puts responsibility back on game companies for the markets they have… or lack. As she formulates it:

> It’s going to take designers that are willing to look at different conflict resolution styles and different learning styles. It’s going to take artists that are willing to rethink how they present avatars. It’s going to take design teams that keep the broad market in mind from the very first lines of the design document, it’s going to take development houses that are willing to examine their hiring practices and make sure they are an option for potential female industry candidates. In short, it’s going to take an industry that is willing to step back and look at their titles, and ask themselves, “But what if the player is a female?”

There are a number of organizations and conferences for women in gaming. See, for example:


Quoting from the Website:

Women In Games International was founded in 2005 in response to a growing demand around the world for the inclusion and advancement of women in the game industry.

Women In Games International is managed by a steering committee comprised of like-minded individuals, is supported by corporate and media sponsors, and directed by a global advisory board. The organization has been developed in partnership with the Women in Games Conference in Dundee, Scotland.


**Student Creation of Games**

As you watch small children at play, you see that they are adept at creating games they find entertaining and attention holding. Many students enjoy creating games for themselves and others. This can be a valuable educational experience. Quoting from Yasmin Kafai (2001):

We have only begun to build a body of experience that will make us believe in the value of game activities for learning. Obviously, the image of children building their own games is as much a "knee-jerk reflex" for constructionists as making instructional games is for instructionists. In the case of instructional games, a great deal of thought is spent by educational designers on content matters, graphical representations, and instructional venues. **The greatest learning benefit remains reserved for those engaged in the design process, the game designers, and not those at the receiving end, the game players.** [Bold added for emphasis.]

The last sentence in the quote applies to most project-oriented educational activities. It provides a good summary of the case for integrating project-based learning as a routine component of instruction in schools.

Here is another quote from Yasmin Kafai (2001):
We know that as many children enjoy playing games according to given rules, they are also constantly modifying rules and inventing their own. Piaget (1951) claimed that these modifications reflected children’s growing understanding of the world. The process of game construction represented for Piaget the ultimate effort by children to master their environment in creating their representations of the world. Turkle (1984) pointed out an interesting parallel between the attractions of playing games and of programming computers. She saw programming as a way for children to build their own worlds. Within this context, children could determine the rules and boundaries governing the game world and become the makers and players of their own games. In contrast, when children play a video game, they are always playing a game programmed by someone else; they are always exploring someone else’s world and deciphering someone else’s mystery. Turkle saw that what she called the holding power of playing purchased video games could be applied to the making or programming of video games.

It is possible to create an interactive computer game in any general-purpose computer programming language designed to facilitate interactivity. BASIC and Logo are programming languages that millions of students have learned and that are quite suitable for game development. Both commercial and free versions of each of these programming languages are available. The Website [http://www.thefreecountry.com/compilers/miscellaneous.shtml](http://www.thefreecountry.com/compilers/miscellaneous.shtml) is a useful starting point for finding free versions of these and other programming languages.

Squeak is a more recently developed computer programming language that is designed for students. It provides an excellent environment for creating games. It is available free at [http://www.squeak.org/Features/](http://www.squeak.org/Features/) for both Mac and Windows platforms.

An alternative approach is to make use of software that has been specifically designed for game development. Game Maker is available free on the Web and provides a good example of such software (Overmars, n.d.). Quoting from Mark Overmars’ Website:

Did you always want to design computer games? But you don't want to spend a lot of time learning how to become a programmer? Then you came to the right place. Game Maker is a program that allows you to make exciting computer games without the need to write a single line of code. Making games with Game Maker is great fun. Using easy to learn drag-and-drop actions you can create professional looking games in little time. You can make games with backgrounds, animated graphics, music and sound effects. And once you get more experienced there is a built-in programming language that gives you full flexibility. What is best, Game Maker can be used free of charge. And you can use the games you produced in any way you like. You can even sell them!

There are many other game-creation resources available. See for example: [http://www.ambrosine.com/resource.html](http://www.ambrosine.com/resource.html). The Website provides many examples of free software available for creating computer games.

**Games and the Aging Brain**

During the past five years, I have become quite interested in brain science and how it relates to education. Also, as I have continued to grow older, I have developed an interest in capabilities of the aging brain.

During the past two decades, there has been substantial progress in brain research. Largely, this has occurred using non-invasive brain scanning equipment. This equipment depends heavily on computer hardware and software. The steady increase in the speed and the cost effectiveness of computer systems has been a major factor in improvement of brain imaging equipment.

It has long been understood that “use it or lose it” applies to one’s physical body. Now, it is also understood that this applies to one’s mind and brain. Gene Cohen is the Director of the

An important 2003 study identified five leisure activities that were associated with a lower risk of dementia and cognitive decline. In order of impact (from highest to lowest), the winners were dancing, playing board games, playing musical instruments, doing crossword puzzles, and reading. Risk reduction was related to the frequency of participation. For example, older persons who did crossword puzzles four days a week had a risk of dementia 47 percent lower than subjects who did puzzles only once a week. [Bold added for emphasis.]

The Fall 2005 article at http://www.gwu.edu/~magazine/2005_research_fall/features/feat_aging.htm discusses Cohen’s work:

They have found that sleep and mood disorders can be alleviated by stimulating the brain; that vocabulary expands well into the 80s among people who continually challenge themselves through reading, writing, and word games; and that an active lifestyle can boost the immune system. [Bold added for emphasis.]

Gene Cohen is now involved in developing games designed to exercise the aging brain. Research in this area seems somewhat limited. The commercial Website Acuity Games http://www.acuitygames.com/research.html includes links to various research studies. (As of 4/2/04, all of the references were 2004 and older.)

If you are “into” physical exercises, then you probably know quite a bit about how often to work out, how long to work out, how hard to work out, and so on. That is, the science of physical workouts is quite well developed. This is not the case for mental workouts.

**Artificial Intelligence**

Throughout my professional career, I have been interested in artificial intelligence. The following is quoted from my 2005 book Brief Introduction to Educational Implications of Artificial Intelligence. The entire book is available free at http://darkwing.uoregon.edu/~moursund/Books/AIBook/index.htm.

Artificial intelligence (AI) is a branch of the field of computer and information science. It focuses on developing hardware and software systems that solve problems and accomplish tasks that—if accomplished by humans—would be considered a display of intelligence. The field of AI includes studying and developing machines such as robots, automatic pilots for airplanes and space ships, and “smart” military weapons. Europeans tend to use the term machine intelligence (MI) instead of the term AI.

The theory and practice of AI is leading to the development of a wide range of artificially intelligent tools. These tools, sometimes working under the guidance of a human and sometimes without external guidance, are able to solve or help solve a steadily increasing range of problems. Over the past 60 years, AI has produced a number of results that are important to students, teachers, our overall educational system, and to our society.

Each computer game makes use of some aspects of AI. For example, when you are playing a computer game, you decide on a move and communicate this to the computer. You might do this by use of a keyboard, mouse, joystick, or verbal command. In some sense, the computer “understands” your specification of a move and checks to see if it is a legal move. If it is not a legal move, the computer tells you so. If it is a legal move, the computer makes the move. It takes a certain amount of intelligence to receive a specified move, decide if is a legal move, and then take appropriate action.
Many computer games make use of considerably more AI. For example, in computer games that require two or more players, the computer may serve as some (or all) of these players. If you like to play games such as checkers and chess, you can play them against a computer opponent. The chances are that this computer opponent has enough checker-playing or chess-playing intelligence to defeat you.

You may have noticed that the definitions of AI do not talk about the computer’s 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.
- 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 seem to 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. To learn more about this topic see Chapter 7 of Moursund (2005).

Many real world problems or problem situations are very large, complex, and interdisciplinary. The translation of speech from one natural language to another provides a good example. While some progress is being made in this area, bilingual humans are far better at such translation than are artificially intelligent computer systems.

There are other more limited and less challenging problem areas in which AI systems are quite successful. Examples include processing loan applications, certain types of medical diagnostic work, and in some Highly Interactive Intelligent Computer-Assisted Learning systems. Computer systems that handle voice input (for example, receiving voice input and producing text as output) are now accurate enough so that many people use them.

The point is, AI is an increasingly important use of computers that affects everyday life in our society. Thus, it is important that students learn some of the characteristics, capabilities, and limitations of AI systems. Games can be a useful part of an environment to study and experiment with AI. A Google search of games and artificial intelligence produces millions of hits. Browsing a few of these hits will give you increased insight into AI and roles of AI in computer games.

**Dangers of too much Game Playing**

It is clear that computers, cell phones, digital cameras, video games, and other aspects of ICT are “here to stay.” Moreover, it is clear that children growing up in this environment tend to be more comfortable with it than many of today’s adults. ICT has already substantially changed the day-to-day life patterns of many people. For example, as I watch college students moving from class to class, I am beginning to wonder if having a cell phone to one’s ear is now an integral component of walking!

Video games are making significant progress having the video and story line quality of broadcast television, along with steadily improving interactivity that allows the viewer to be an active participant in the story. In that sense, a video game can be thought of as video plus interactive participation. It is not surprising that large numbers of children spend more time playing video games than they do watching (non interactive) television.
There is a substantial and growing literature on actual and possible harms of children and adults spending so much time playing video games and making other uses of ICT. My personal collection of such materials can be accessed at http://otec.uoregon.edu/arguments_against.htm.

Such arguments against use or over use of ICT tends to fall into two major categories:

1. Arguments that use or overuse of ICT causes physical and/or mental damage. For example, huge numbers of people develop carpel tunnel syndrome. There is growing evidence of increasing obesity in children due to not getting enough physical exercise. There are continuing concerns that cell phones may cause brain damage; there is strong evidence of loud audio devices causing hearing damage.

2. Arguments that video games and other ICT are addictive and take time away from other activities that are important parts of becoming a well rounded, responsible adult, and productive adult.

Schools are struggling with how to make appropriate use of ICT as an aid to learning and, at the same time, restrict or prohibit use of ICT that draws student attention away from learning the content being taught in schools, is disruptive in classrooms, is used to cheat on tests, is used to harass students, is used by stalkers, and so on.

Douglass Gentile (n.d.) discusses some of the standard arguments against young children spending too much time playing video games. His brief article concludes with the statement:

It's important to remember, however, that video and computer games aren't all bad. Quality games give children the opportunity to practice problem solving and logic skills. They increase fine motor and coordination skills and foster an interest in information technology. And, if you are playing the games with your child — something I highly recommend — they provide an occasion for you to do something together. Your best bet is to limit video game playing now while your child is still young. In addition, be a smart consumer and choose video games for your child that are age appropriate and that aren't sending the wrong message.

Knowledge-Building Communities

A number of people are doing research in the field of games in education. A good foundation for some of this research has been provided by Scardamalia and Bereiter (1994). Their article includes a focus on three important aspects of education that are also important aspects of using games in education;

1. Intentional learning. Quoting from their article:

   Although a great deal of learning is unintentional, important kinds of school learning appear not to take place unless the student is actively trying to achieve a cognitive objective - as distinct from simply trying to do well on school tasks or activities (Bereiter & Scardamalia, 1989; Chan, Burtis, Scardamalia, & Bereiter, 1992; Ng & Bereiter, 1991).

   As pointed out elsewhere in this book, effective use of games in education requires that they be used in an intentional learning environment.

2. Expertise is a process. Quoting from Scardamalia and Bereiter (1994):

   Although expertise is usually gauged by performance, there is a process aspect to expertise, which we hypothesize to consist of reinvestment of mental resources that become available as a result of pattern learning and automaticity, and more particularly their reinvestment in progressive problem solving - addressing the problems of one's domain at increasing levels of complexity (Bereiter & Scardamalia,
1993; Scardamalia & Bereiter, 1991b). Progressive problem solving characterizes not only people on their way to becoming experts, but it also characterizes experts when they are working at the edges of their competence. Among students, the process of expertise manifests itself as intentional learning.

We want students to develop their levels of expertise in many different areas. Research indicates that students should understand this educational goal, understand the meaning of expertise, and be actively engaged in developing their own expertise.


The process of expertise is effortful and typically requires social support. By implication, the same is true of intentional learning. Most social environments do not provide such support. They are what we call first-order environments. Adaptation to the environment involves learning, but the learning is asymptotic. One becomes an old timer, comfortably integrated into a relatively stable system of routines (Lave & Wenger, 1991). As we explain further in later sections, there is good reason to characterize schools of both didactic and child-centered orientations as first-order environments. In second-order environments, learning is not asymptotic because what one person does in adapting changes the environment so that others must readapt. Competitive sports and businesses are examples of second-order environments, in which the accomplishments of participants keep raising the standard that the others strive for. More relevant examples in education are the sciences and other learned disciplines in which adaptation involves making contributions to collective knowledge. Because this very activity increases the collective knowledge, continued adaptation requires contributions beyond what is already known, thus producing non-asymptotic learning. The idea of schools as knowledge-building communities is the idea of making them into second-order environments on this model.

One of the key ideas here is that of a steadily rising bar. The totality of human knowledge is steadily growing. Many people talk about the idea of an information overload—that there is too much information that we need to deal with. Somehow or other our schools should be helping students learn to deal with this information overload.

In some sense, the world we live in is growing more complex. The problems an ordinary person faces in day to day living are growing more complex. I like to think of this as a problem overload. I am continually bombarded by problem situations, in a manner suggesting I should take ownership and accept the problem situations as personal problems. A couple of hours of watching commercial television and news, and I am overwhelmed. Some of the world’s best marketing people are doing their best in feeding me problem situations (be it bad breath, heartburn, starving children through the world, crime in my own city, and so on) that I must do something about immediately.

In some sense, the difficulty is not an information overload. It is a lack of easily accessible information to deal with the problem overload. I lack the information to quickly and easily deal with all of these problem situations that are being forced upon me!

**Static and Virtual Math Manipulatives**

Math educators often make use of math manipulatives in helping their students to better understand mathematics. Many of these manipulatives have game-like characteristics. A brief discussion of computer-based math manipulatives (virtual manipulatives) and links to a number of virtual manipulative Websites are available at
http://otec.uoregon.edu/virtual_manipulatives.htm, Quoting from the Website http://www.ct4me.net/math_manipulatives.htm:

In *What are Virtual Manipulatives?*, Patricia Moyer, Johnna Bolyard, and Mark Spikell (2002) define a virtual manipulative as "an interactive, Web-based visual representation of a dynamic object that presents opportunities for constructing mathematical knowledge" (p. 373). Static and dynamic virtual models can be found on the Web, but static models are not true virtual manipulatives. Static models look like physical concrete manipulatives that have traditionally been used in classrooms, but they are essentially pictures and learners cannot actually manipulate them. … The key is for students to be able to construct meaning on their own by using the mouse to control physical actions of objects by sliding, flipping, turning, and rotating them.

Many virtual manipulatives are computer simulations of physical manipulatives. This situation provides a good example of the “computational” in sub disciplines such as computational math, biology, and physics. It also helps to illustrate computational thinking. If I can develop a computer model of a problem situation I am thinking about or some project I am doing, I can take advantage of the computer model in doing the thinking and the project. Part of computational thinking is to think about use of computational modeling when faced by challenging problems and tasks.

Tangram serves as a nice example of a physical and virtual manipulative. This is a Chinese puzzle consisting of a square cut into five triangles, a square, and a rhomboid, to be reassembled into different figures with no overlapping pieces (Tangram, n.d.). Figure 9.1 shows the seven pieces and the pieces arranged into a running person. Tangram is available for free online play at http://www.apples4theteacher.com/tangrams.html. (Ten examples are shown. Use the Help button for directions.)

![Figure 9.1. The seven Tangram pieces and a running person.](image)

**Research on Games and Gaming**

Many people view computer games as an opportunity to help improve our educational system. James Paul Gee is a professor of reading at the University of Wisconsin-Madison and a leader in educational uses of computer games. He notes that computer games are often quite complex and present a serious learning challenge. Quoting from (Gee, 2004):

For people interested in learning, this raises an interesting question. How do good game designers manage to get new players to learn their long, complex, and difficult games—not only learn them, but pay to do so? It won’t do simply to say games are “motivating”. That just begs the question of “Why?” Why is a long, complex, and difficult game motivating? I believe it is something about how games are designed to trigger learning that makes them so deeply motivating.
Two researchers at Brunel University recently reported on their three-year study of gaming (Brunel University, 2006). Quoting from the press release:

Brunel academics today unveil the results of a three-year study into online gaming communities, which defies the traditional educationalists' negative perception of gaming. The academics believe that computer games have a central role to play in the education and development of young people, contributing to the Qualifications and Curriculum Authority's strategy of work related learning, which helps children make an effective transition from school to work.

The study, which took the form of qualitative research into a community of players of the online game Runescape shows that gaming is far from being a frivolous diversion from homework. The research shows how the online worlds created by the gamers mirror many aspects of material society helping teenage gamers to make the transition from school to work. For example, gamers are invited to join 'Klans' - highly disciplined co-operatives in which they share a common set of goals, they adopt identities such as merchant or warrior and they divide their time online between work and leisure. Most importantly, skills are learnt which are highly valued, with experienced players tailoring their 'training' to acquire the 'desirable' skills - a clear example of 'work related learning'.

Many of today’s popular computer games are multiplayer, first person shooter (FPS) games. In such games, a game player controls a “person” or avatar who is a member of a team, playing against the computer and/or against other teams (Wright et al., 2002). The referenced article includes an emphasis on the social interaction that goes on in such a game. Quoting from this research article:

Play is not just "playing the game," but "playing with the rules of the game" and is best shown in the diversity of talk, the creative uses of such talk and player behavior within the game, plus the modifications of game technical features. Of course, the playing of the game also produces changes in one's own subjectivity making it a pleasurable experience if one is accomplished (Myers 1992). In essence, the game is a platform for showing off human performances in a mock combat setting. But, all is not combat or simply shooting a virtual enemy. And, as in any human performance, creativity of execution is the norm.

From our text files we identified 39 possible coded talk categories which fit into the following five general categories: 1) creative game talk, 2) game conflict talk, 3) insult/distancing talk, 4), performance talk and 5) game technical/external talk. These were the categories that appeared to exhibit the greatest frequency of use among players. They give a direct insight into the types of social interactions and the "policing" of such interactions in these types of action games.

A number of people and groups are now engaged in research and development of educational computer games. Kurt Squire at the University of Wisconsin-Madison is a leading researcher in this field. Quoting from Massachusetts Institute of Technologies’ Games-to Teach Website (Squires, n.d.):

The most under-examined potential of games may be their impact as an educational medium. Playing games, I can relive historical eras (as in Pirates!), investigate complex systems like the Earth's chemical & life cycles (SimEarth), govern island nations (Tropico), manage complex industrial empires (Railroad Tycoon), or, indeed, run an entire civilization (Civilization series). Did I forget to mention travel in time to Ancient Greece (Caesar I,II, & III), Rome (Age of Empires I, and II), relive European colonization of the Americas (Colonization), or manage an ant colony, farm, hospital, skyscraper, theme park, zoo, airport, or fast food chain? As my opening anecdote suggests, the impact of games on millions of gamers who grew up playing best-selling games such as SimCity, Pirates!, or Civilization is starting to be felt. Perhaps there are important cultural questions beyond "Do games cause violence?" that academics could begin exploring.

Squire’s paper contains an extensive bibliography and provides good evidence of the growing research literature in this discipline.
Serious Games

The term serious games is now used to describe games that are designed for non-educational purposes. Quoting from Katrin Becker (n.d.):

The use of computer and video games for learning is an emerging area of research, and interest is growing rapidly. As a sub-field of Serious Games, digital game-based learning poses some unique problems and challenges. As more and more young people grow up with digital games as one of their primary forms of entertainment, it behooves us to become familiar with this genre, how it affects people, and how we might use it for educational goals. Computer technology has advanced to the point where it is feasible (we now have the horse-power to accomplish this) to use games in a classroom setting. "Computer pioneer Alan Kay (DARPA in the '60s, PARC in the '70s, now HP Labs) declares 'The sad truth is that 20 years or so of commercialization have almost completely missed the point of what personal computing is about.' He believes that PCs should be tools for creativity and learning, and they are falling short."

If you are interested in some of the current Serious Games ideas and research, you might enjoy reading the notes published by an attendee at the two-day Serious Games Summit held October 31 and November 1, 2005. The notes are available at http://www.mcmains.net/ruminations/2005/11/01. The posting starts with Day 2, but contains Day 1 later in the posting.

Marc Prensky’s Website is an excellent resource on serious games. Quoting from http://www.socialimpactgames.com/:

Welcome to our revised site, which now boasts an index (see left). All the content on this site (except comments) is available without logging in. We have now identified over 500 serious games, which we are in the process of adding to this list."


1. Games are a form of fun. That gives us enjoyment and pleasure.
2. Games are form of play. That gives us intense and passionate involvement.
3. Games have rules. That gives us structure.
4. Games have goals. That gives us motivation.
5. Games are interactive. That gives us doing.
6. Games are adaptive. That gives us flow.
7. Games have outcomes and feedback. That gives us learning.
8. Games have win states. That gives us ego gratification.
9. Games have conflict/competition/challenge/opposition. That gives us adrenaline.
10. Games have problem solving. That sparks our creativity.
11. Games have interaction. That gives us social groups.
12. Games have representation and story. That gives us emotion.
Activities for the Reader

1. Engage your students in a discussion about why girls and boys don’t necessarily like the same types of games. You might want to do whole class or small group brain storming about what might make a game more appealing to girls than boys, or vice versa.

2. Chapter 5 of Marc Penzsky’s 2001 book contains a list of 12 characteristics of games. Select some traditional school academic discipline or topic that you teach. Analyze it in terms of the 12-item. One way to do this would be to develop a 5-point scale, ranging from very low to very high. Select a game that you know well, and school discipline or topic that you know well. Rate the game and the school topic on each of the 12 items in the list.

Activities for use with Students

1. Working in teams of two or three, create a game. One possible starting point is to make a list of characterizes that make a game “fun” to members of the team, and then to design a game that has a number of these characteristics. During the game developmental process, a team may want to try out some of their ideas with members of other teams. After each team has created a game, the teams can demonstrate and teach their games to the whole class.

2. Do whole class brainstorming on what makes a game fun. After a large number of characteristics have been developed, pair the list down to a half dozen or so, perhaps by using a voting technique in which each student is given a limited number of sticky dots to place on their top choices. Then divide the class into small teams, with each team being given a subject that they are studying in school. Each team is to analyze their subject and the way it is being taught in terms of the characteristics that make a game fun.
Appendix 1

Summary of Problem-solving Strategies

We all make use of strategies as we attempt to solve problems and accomplish tasks. The research literature in problem solving indicates that most people have a relatively limited repertoire of problem-solving strategies. This research suggests that it is helpful to increase one’s repertoire of problem-solving strategies. Teaching for high-road transfer of learning is an effective method of helping students to increase their repertoire.

However, increasing the size of one’s repertoire of problem-solving strategies is only one part of increasing one’s level of expertise in problem solving. Problem solving in a specific domain requires knowledge that is specific to the domain. Increasing expertise in problem solving in a domain requires substantial cognitive effort. It does little good to memorize a bunch of strategies. One must consciously practice using the strategies and reflect on the results over a large range of problems.

The following alphabetical list contains problem-solving strategies that cut across many problem-solving domains. Most are discussed and illustrated earlier in this book. The teaching of such strategies can be integrated throughout the daily curriculum.

backtracking. Taking back or undoing one or more moves that one has made in playing a game or in attempting to solve a problem. This is especially easy to do when the steps being taken are “virtual” steps, working with a computer representation of the problem and the steps being taken.

backward. See work backward.

bottleneck. Identify components of a problem-solving task that severely impede progress toward solving the problem. Particularly useful in problems where certain resources such as time or materials are severely restricted or a goal is to minimize their use.

brain aids. Many computer games include built-in aids to a player’s brain/mind. Thus, it is now commonplace for a game player to think about having the computer aid in playing the game. There are many articles about the nature and extent of the artificial intelligence (AI) built into various games. In some instances, such uses of AI as an aid to problem solving illustrate or are somewhat parallel to uses of AI to help solve non-game types of problems.

breaking a problem into smaller problems. See divide and conquer.

build on previous work. See reinvent the wheel.

collaboration and cooperation. There are many problem-solving situations where “two heads are better than one.” Indeed, there are many problems and tasks that require the work of large teams of people together over a period of years.
collect data. Think of playing a game or attempting to solve a problem as a research process. Think of yourself as a “scientific” researcher, carefully gathering data about the moves you are making or thinking about making and the strategies you are using, and then analyzing the results that are obtained from a particular move. You can see that this is essentially the same process as the scientific method that researchers use. Thus, this is an excellent opportunity for high-road transfer of learning.

create a simpler problem. When faced by a problem that you cannot solve, create a somewhat similar or related problem that is challenging, but perhaps not as difficult. Working to solve the new problem may give you insights that will help you to solve the original problem.

divide and conquer. Divide a large problem into smaller sub-problems that are more manageable. Do this in a manner such that once the sub-problems are solved, it is relatively easy to put the pieces together to solve the original problem. Note the value of having a large repertoire of “sub-problems” that one can readily solve. Often, some of the sub-problems can be solved by a computer or other machine.

domain-specific. Most of the strategies listed in this appendix are applicable in many different game and non-game problem-solving situations. Within any problem-solving or game domain, there are strategies that are quite specific to the domain. These are called domain-specific problem-solving strategies For example, play in the center square if you are the first player in a TTT game. This is a good TTT strategy because if your opponent responds by playing in the center of any of the four edges, you can then force a win. If your opponent plays in a corner, you can easily avoid losing.

don’t box yourself into a corner. See mobility.

elimination. In many problems, it is possible to relatively quickly and easily eliminate certain categories of potential solutions or approaches. This narrows the things that one needs to think about or try out in an attempt to solve the problem.

exhaustive search. Many problems can be solved by trying out all possible (allowable, applicable) moves or sequences of moves. If the number of possibilities is relatively small, a person or team of people might be able to carry out such an exhaustive search in a timely fashion. If the search process can be carried out by a computer, it may be possible to explore many millions of possible solutions or sequences of moves.

explore solvability. Many of the situations that people call problems are actually not clearly defined and understandable problems. Rather, they are problem situations. One of the first steps to take when faced by a problem situation is to explore whether it is actually a clearly defined problem (given initial situation, clear goal, resources, ownership). One does not solve a problem situation, one solves a problem. Next, spend some time exploring whether you actually understand the problem. If you don’t understand the given initial situation, the goal, and the resources, you are not in a good situation to attempt to solve the problem. One way to increase your understanding of a problem is to consider whether the problem might not have a solution. Think to yourself: “how would I recognize a solution if I happened to find one?”

good start. Quoting Aristotle, “Well begun is half done.” Quoting Lao Tzu, “A journey of a thousand miles must begin with a single step.” In problem solving, a good start or a good
first step is one that is likely to make a significant contribution to solving the problem. In competitive two-player games such as chess, many thousands of person hours of effort have gone into analyzing opening sequence of moves. Knowledge of and use of “good” openings can give a player a substantial advantage over an opponent who is less familiar with this form of accumulated knowledge.

**guess and check.** See *guess and learn.*

**guess and learn.** Many problems can be approached by making a guess (sometimes called an “educated guess”) at a solution or a possible approach to obtaining a solution. If the guess provides a correct solution or a correct pathway to obtaining a solution, that is well and good. If it doesn’t, then one still gains useful information about the problem. For example, if one makes a guess of a solution and the guess is incorrect, one learns that the guess is incorrect. However, in many problem-solving situations, one gains additional information that helps in making a better guess or helps in developing a better plan. Generally speaking, increasing one’s expertise in problem solving in a particular domain includes getting better at making educated guesses and making guesses that are useful aids to learning more about how to solve a problem in the domain.

**hill climbing.** See *incremental improvement.*

**incremental improvement.** Some problems can be solved through a sequence of incremental improvements. This is somewhat akin to walking to the top of a mountain by making sure each step moves you uphill. However, many problems cannot be solved by incremental improvement (think of climbing a mountain and having to move down hill from time to time). Thus, incremental improvement is often a poor strategy, wasting time and other resources, and contributing little to actually solving the problem.

**information retrieval.** See *reinvent the wheel.*

**learn to fill in the details.** A powerful alternative to rote memory is to learn/understand general approaches to solving certain types of problems, accomplishing certain types of tasks, and making certain proofs. With the general understanding, one can then fill in the details. This is a common teaching technique in math and is applicable to any problem solving instruction.

**letter frequency.** Data has been collected on the frequency of use of each letter of the English alphabet in typical writing. Also, data has been collected on most frequent beginnings of words and end of words, most common bigrams, most common trigrams, and so on. A person can memorize such detailed data, and it can be incorporated in computer programs. The data is useful in cryptography, working to identify the author of a manuscript, and in a variety of games. Letter frequency is a good example of building on the previous work of others—through memorization or through use of a machine such as a computer.

**long-range planning.** This is often called *long-range strategic planning.* It refers to developing a broad, strategic plan that provides a good sense of direction of where one is heading in trying to solve a particular problem. Often a long-range strategic plan is accompanied by shorter-range plans and strategies, and by detailed tactics that are designed to accomplish the short range plans.
**look ahead.** Typically, solving a problem involves a sequence of steps or moves. In there is an opponent involved, then moves are followed by responses that might well affect one’s next move. In attempting to solve real-world problems, each step or action makes a change in the problem situation. Failure to anticipate major changes often leads to failure to solve a problem.

**look before you leap.** See: *think before you act; look ahead; good start.*

**memorize when personally effort-effective.** This is a strategy applicable to a wide variety of problem-solving situations. Memorized information can be thought of as solutions to specific sub-problems or problems. People vary considerably in terms of how quickly and accurately they can memorize a particular set of materials, and how long and accurately they retain the memorized information. A rule of thumb is to memorize information that one needs to use frequently enough, and in a time-dependent manner, to make the memorization effort worthwhile. Keep in mind the capabilities of a computer system to store the full contents of millions of books, and the abilities of search engines to aid in retrieval of information stored in a computer.

**mental aids.** Reading, writing, arithmetic, books, and computers are all examples of mental aids. They help to overcome limitations of one’s brain. They are resources that can be applied to problems in every domain. See *modeling and simulation.*

**metacognition.** Metacognition is thinking about—analyzing, reflecting on—one’s thinking. It is a highly effective strategy in improving one’s problem-solving and learning skills.

**metaphor.** See *modeling and simulation.* A metaphor is “the application of a word or phrase to somebody or something that is not meant literally but to make a comparison, for example, saying that somebody is a snake” (Encarta® World English Dictionary © 1999 Microsoft Corporation). In some sense, most written and oral language is metaphorical. It is an attempt to provide a written or oral representation of something, where the words and sounds are not the actual thing being represented. When describing and thinking about a problem, metaphors can be a powerful aid to understanding or constructing understanding, thinking, and thinking outside the box.

**mobility.** As you work to solve a challenging problem, don’t close off options that may later prove to be fruitful. Don’t box yourself into a corner where you have very few or no options.

**modeling and simulation.** The development of models and then the use of these models (for example, develop a model of an airplane and test it in a wind tunnel) has long been a powerful tool in problem solving. Computer modeling and simulation is such a powerful aid to problem solving that it has added a new dimension to how science is done. Nowadays, science is done experimentally (designing and carrying out experiments), theoretically (developing theories, such as Einstein’s theory of relativity), and computationally (developing and using computer models). Spreadsheet software is a powerful aid to modeling many business problems and then answering “What if?” types of questions.

**Moursund’s 7-step strategy.** This is a seven-part set of advice that can be used to get better at solving a wide range of problems. It summarizes ideas such as learning general knowledge
and strategies, learning domain-specific knowledge and strategies, and learning during the process of solving a problem.

**patterns.** This is a short name for strategies such as *look for patterns* and *make use of patterns*. I find it helpful to think of randomness as being the absence of patterns. The human brain can be thought of as an organ for the input, storage, processing, and use of patterns. (That statement is quite similar to the statement that an electronic digital computer is a machine for the input, storage, processing, and output of data and information.) The identification and use of patterns is a key aspect of problem solving in every discipline.

**problem situation.** Many of the things that people describe as problems are actually problem situations. They lack one or more of the characteristics (givens, goal, resources, ownership) to be clearly defined problem of personal interest. Polya’s six-step strategy begins with understanding the problem—determining if one actually has a clearly defined problem that he or she is interested in solving.

**random.** See *patterns*. Somewhat surprisingly, the use of random moves or random activity can be a useful approach in many different problem-solving situations. Of course, many games make use of randomness. For example, one shuffles the cards in card-based games of solitaire and in many other card games. One makes use of a spinner or dice into generate moves in many different games. At a deeper level, randomness can be used in modeling and simulation as an aid to solving a wide range of problems in science and other areas. For a more mundane example, imaging a person playing a game such as Tic-Tac-Toe by making completely random moves. The results can be used to establish baseline data on how well a person plays the game before developing or learning any strategies that lead to an improved level of play.

**record one's moves.** See *collect data*. See *mental aids*.

**reinvent the wheel.** This strategy takes two forms: 1) *don’t* reinvent the wheel; 2) *do* reinvent the wheel. In the first instance, the idea is to build upon work that you and others have done in the past. Use Web and other resources of stored information—do library research—research to find out what is already known about how to solve a particular problem. In the second instance, the idea is to not be boxed in by conventional approaches to the problem. This approach is also a key in learning how to solve problems. There, the goal is to improve one’s level of expertise in solving novel, challenging problems.

**score and then improve your score.** See *good start*. There are many real-world problem solving situations in which a score of zero is explicitly or implicitly given for not making a reasonable attempt, or completely failing in one’s attempts. In many tests, one can get partial credit for a good start, even if one fails to actually solve the problem.

**sequence of moves.** See *look ahead*. In many card and board games and in many puzzles it is important to think in terms of sequences of moves. Through training and experience, one can become quite skilled at mentally (in one’s mind’s eye) examining a sequence of possible moves.

**simpler problem.** See *create a simpler problem*. When faced by a challenging, complex problem, create a simpler but closely related problem and attempt to solve it. The goal is to gain insight into the original problem. For example, instead of thinking about how to
reduce hunger in the United States, think about reducing hunger in your state, or in your city, or in one small area in your city, or the hunger that you know exists for one student in a class you are teaching. For another example, consider the problem of learning the rules of a complex game. Set yourself the simpler problem of learning the rules for making your first move.

**strategize.** The list of high-road transferable problem-solving strategies illustrated in this book is designed to help you get better at developing and using problem-solving strategies. A strategy can be thought of as a plan of action to be used in attempting to achieve a goal. Some strategies are general purpose, useful over a wide range of problems. However, typically it takes considerable domain-specific knowledge and skills to solve a challenging problem within a specific domain. As one develops such domain-specific knowledge and skills, one develops specific strategies (or, fine tunes general strategies) to better fit the problem-solving requirements of the domain.

**think before you act.** This is sometimes called *look before you leap*, or *engage brain before opening mouth*. Some problem-solving situations require immediate (stimulus-response; intuitive) actions be taken. There is no time to think. The strategy that is emphasized in such situations might be called *act before you think*. Of course, the actions you take may be based on a huge amount of training and practice. Many problem-solving situations do not require immediate, split second responses and actions. In these situations, there is time to mull over possible actions, to think before taking an action.

**think out loud.** When a team of two or more people are working on a problem, it is often helpful to have one member of the team think out loud about the problem, while the other team members merely listen and perhaps take notes. A different approach is to have two or more members of the team thinking out loud, interchanging possible strategies and ideas, as they explore and work on the problem.

**think outside the box.** When faced by a problem, most people have a strong tendency to use the approaches and take the types of problem-solving steps that are familiar and comfortable to them. If this does not work, a standard next step is seek help from others, perhaps directly from other people or through library research. There are many problems where these approaches do not work. Solving the problems requires developing new ideas, new ways of thinking, new inventions. It may involve deliberately ignoring ideas and approaches that first come to mind, or that others have developed. Individual and group brainstorming can sometimes be an effective aid to thinking outside the box.

**work backward.** Start at a solution and move back one or more steps in a manner such that it is easy to see how to move forward to a solution. In essence, the strategy is to create a new problem to solve, with the new problem having the characteristic that once it is solved, it is easy to solve the original problem. See *simpler problem*. 


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