Introduction to Using Games in Education: A Guide for Teachers and Parents

6/26/06; a few small corrections were added 8/06/06

Dave Moursund
Teacher Education, College of Education
University of Oregon 97403
Email: moursund@uoregon.edu
Web: http://darkwing.uoregon.edu/~moursund/dave/index.htm

Contents .............................................................................................................. 1
About Dave Moursund, the Author .............................................................. 5
Preface ........................................................................................................... 6
Learning Through Game Playing ............................................................... 6
Computational Thinking ............................................................................. 7
Puzzles ........................................................................................................... 8
Brief Overview of Contents ......................................................................... 8
Chapter 1: Thinking Outside the Box ........................................................... 10
Puzzle Problems ......................................................................................... 11
Problems and Problem Solving ................................................................. 14
Problem Solving is Part of Every Discipline ............................................. 16
Cognitive Maturity ...................................................................................... 17
George Polya’s General Problem-Solving Strategy .................................... 18
Modeling and Simulation ........................................................................... 19
Games Can be Addictive ........................................................................... 20
Final Remarks .............................................................................................. 21
Activities for the Reader ............................................................................. 22
Activities for use with Students ................................................................. 23
Chapter 2: Background Information ......................................................... 25
Types of Games Considered in this Book ................................................. 25
Games-in-Education as a Discipline of Study ........................................... 28
Activities for use with Students ........................................ 74

Chapter 5: One-Player Games ............................................. 77
Learning to Play a Game .................................................... 77
Solitaire (Patience) ......................................................... 78
The Solitaire Game Eight Off ............................................ 82
Tetris ................................................................. 92
Final Remarks .............................................................. 93
Activities for the Reader .................................................. 93
Activities for use with Students ........................................ 93

Chapter 6: Two-Player Games ............................................. 95
Tic-Tac-Toe ............................................................... 95
Chess ................................................................. 101
Checkers ............................................................... 103
Hangman .............................................................. 104
Othello (Reversi) ......................................................... 106
Dots and Boxes ......................................................... 110
Cribbage ............................................................. 111
Activities for the Reader ................................................ 112
Activities for use with Students ........................................ 113

Chapter 7: Games for Small & Large Groups ....................... 114
Monopoly ............................................................... 114
Hearts ................................................................. 115
Card Sense ............................................................ 117
Oh Heck: A Trick-Taking Card Game ......................... 118
Whist: A Trick-Taking Card Game ................................. 119
Bridge: A Trick-Taking Card Game ................................. 120
Massively Multiplayer Online Games (MMOG) ................ 121
Star Trek’s Holodeck .................................................. 123
Final Remarks: Moursund’s 7-Step Advice .................... 124
Activities for the Reader ................................................ 125
Activities for use with Students ........................................ 125

Chapter 8: Lesson Planning and Implementation .............. 126
Roles of a Teacher ....................................................... 126
Learning to Learn ....................................................... 127
Lesson Plan Ideas ....................................................... 129
More Specific Educational Goals ...................................... 131
About Dave Moursund, the Author

Dave Moursund
Teacher Education, College of Education
University of Oregon
Eugene, Oregon 97403
Email: moursund@uoregon.edu
Web: http://darkwing.uoregon.edu/~moursund/dave/index.htm

• Doctorate in mathematics (numerical analysis) from 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 Professor and then Full Professor, Department of Computer Science, University of Oregon.
• Served six years as the first Head of the Computer Science Department at the University of Oregon.
• In 1974, started the publication that eventually became Learning and Leading with Technology, the flagship publication of the International Society for Technology in Education (ISTE).
• In 1979, founded the International Society for Technology in Education. Headed this organization for 19 years.
• Full Professor in the College of Education at the UO for more than 20 years.
• Author or co-author of about 40 books and several hundred articles in the field of computers in education.
• Presented about 200 workshops on various topics in the field of computers in education.
• Served as a major professor for about 50 doctoral students (six in math, the rest in education). Served on the doctoral committees of about 25 other students.
• For more information about Dave Moursund and for free (online, no cost) access to 20 of his books and a number of articles, go to http://darkwing.uoregon.edu/~moursund/dave/.
Preface

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

There are many other types of games that are not explored in this book. For example, I do not explore sports games, such as Baseball, Basketball, Football, and Soccer, or any of the sports in the summer and winter Olympic Games.

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 that I played as a child.

In recent years, a number of educators and educational researchers have come to realize that games can be an important component of both informal and formal education. This has become a legitimate area of study and research.

There are oodles of games that are now available in electronic format. While many of these are distributed commercially, many others are available for free play on the Web, and some can be downloaded at no cost. In this book, I am especially interested in games that are available at little or no cost and that have significant educational value.

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 that allow many thousands of players to be participating simultaneously. The computerized animation and interaction in these games bring a dimension to games.

**Learning Through Game Playing**

This book is written for people who are interested in helping children learn *through* games and learn *about* games. The intended audience includes teachers, parents and grandparents, and
all others who want to learn more about how games can be effectively used in education. Special emphasis is given to roles of games in a formal school setting.

As you know, education has many goals, and there is a huge amount of research and practitioner knowledge about teaching and learning. This book is well rooted in this research and practitioner knowledge. Five of the important ideas that are stressed include:

• Learning to learn.
• Learning about one’s strengths and weaknesses as a learner.
• Becoming better at solving challenging problems and accomplishing challenging tasks.
• Transfer of learning from game-playing environments to other environments.
• Intrinsic motivation—students being engaged because they want to be engaged. This idea is illustrated by the following 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. Like it or not, the phenomenon of video games is clearly a highly significant component of contemporary American children's culture and a highly significant indicator of something (though we may not fully understand what this is) about its role in the energizing of behavior (Kafai, 2001). [Bold added for emphasis.]

Computational Thinking

Your mind/brain learns by developing and storing patterns. As you work to solve a problem or accomplish a task, (as you think) you draw upon these stored patterns of data, information, knowledge, and wisdom.

Beginning more than 5,000 years ago, reading and writing have become more and more important as a mind/brain aid. In the past few decades, computers have contributed substantially to mind/brain processes by providing improved access to information, improved communication, and aids to automating certain types of “thinking” processes.

Notice how the thinking of mind/brain and the thinking (information processing) of computers are melded together in the following brief discussion of computational thinking.

Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine. Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone. Computational thinking confronts the riddle of machine intelligence: What can humans do better than computers, and What can computers do better than humans? Most fundamentally it addresses the question: What is computable? Today, we know only parts of the answer to such questions.

Computational thinking is a fundamental skill for everybody, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child’s analytical ability. (Wing, 2006)

Games provide an excellent environment to explore ideas of computational thinking. The fact that many games are available both in a non-computerized form and in a computerized form
helps to create this excellent learning environment. A modern education prepares students to be productive and responsible adult citizens in a world in which mind/brain and computer working together is a common approach to solving problems and accomplishing tasks.

**Puzzles**

A puzzle is a type of game. To better understand the purpose of this book, think about some popular puzzles such as crossword puzzles, jigsaw puzzles, and logic puzzles (often called brain teasers). In every case, the puzzle-solver’s goal is to solve a particular mentally challenging problem or accomplish a particular mentally challenging task.

Many people are hooked on certain types of puzzles. For example, some people cannot start the day without spending time on the crossword puzzle in their morning newspaper. In some sense, they have a type of addiction to crossword puzzles. The fun is in meeting the challenge of the puzzle—making some or a lot of progress in completing the puzzle.

Crossword puzzles draw upon one’s general knowledge, recall of words defined or suggested by short definitions or pieces of information, and spelling. Through study and practice, a person learns some useful strategies and can make considerable gains in crossword puzzle-solving expertise. Doing a crossword puzzle is like doing a certain type of brain exercise. In recent years, research has provided evidence that such brain exercises help stave off the dementia and Alzheimer’s disease that are so common in old people.

From an educational point of view, it is clear that solving crossword puzzles helps to maintain and improve one’s vocabulary, spelling skills, and knowledge of many miscellaneous tidbits of information. Solving crossword puzzles tends to contribute to one’s self esteem. For many people, their expertise in solving crossword puzzles plays a role in their social interaction with other people.

**Brief Overview of Contents**

Each chapter ends with a set of activities for the reader of the book, and a set of activities that might be useful with students of varying backgrounds and interests.

Chapter 1 illustrates the idea of thinking outside the box. This idea is important in solving puzzle problems, but it is also essential in solving many real-world problems.

Chapter 2 provides some general educational background needed in the rest of the book.

Chapter 3 uses a puzzle called Sudoku to explore some aspects of puzzles and their roles in education.

Chapter 4 explores some additional puzzles and sources of free puzzles on the Web.

Chapter 5 explores solitaire card games that can be played with ordinary decks of 52 playing cards, or that can be played on a computer.

Chapter 6 explores competitive 2-person games such as checkers, chess, and backgammon. Nowadays, many people play these games using a computer as an opponent.

Chapter 7 explores games that typically involve more than two players, but only a modest number of players. Examples include Poker, Bridge, and Hearts.

Chapter 8 discusses the development of game-based lesson plans.
Chapter 9 provides very brief introductions to a miscellaneous collection of ideas related to the topic of games in education. If I were writing a longer book, some of these topics would be individual chapters.

Appendix 1 summarizes the problem-solving strategies explored in the book. It also provides additional information about effective ways to use games in education.

David Moursund
Chapter 1

Thinking Outside the Box

We can't solve problems by using the same kind of thinking we used when we created them. (Einstein, Albert)

The vertical thinker says: 'I know what I am looking for.' The lateral thinker says: 'I am looking but I won't know what I am looking for until I have found it.'" (Edward de Bono)

Consider the following two statements:

• Education has many goals. Few people would list “to be fun” as one of the main goals of education. Instead, people tend to say “no pain, no gain.”

• Many games are used as a form of play. Games are for fun.

Now, think back to your childhood. I’ll bet that you can think of games that you played that were fun and made significant contributions to your learning. A personal example that comes to mind is the game of Monopoly. I probably spent hundreds of hours playing this game.

Indeed, as a child I enjoyed playing many different card games, board games that involved dice or spinners, and board games such as Checkers, Chess, and Go that do not depend on randomness. As a young adult I learned to play Bridge, and since then have learned to play a wide variety of computer games.

Games have contributed significantly to my informal and formal learning. Playing games that involved two or more people was an important component of my social development and social life. Game playing was such an important part of my childhood that I made sure it was a part of my children’s childhoods.

In recent years, computers have made possible some new types of games. In addition, computers have made many older games more accessible.

As you read this book, I want you to think outside of the box. Suspend some of your suspicions and beliefs about educational and other values of games. Open your mind to new possibilities. For example, as a child I enjoyed interacting with a small group of people playing Monopoly and other board games. Now, there are computer-based games in which tens of thousands of people simultaneously play in a combination of cooperative and completive manners. This is made possible by the Internet and by the development of games designed to
accommodate huge numbers of simultaneous players. Whether it is just a few people, or a few thousand people playing a computer-based game, they are learning to communicate and interact in a computer-supported environment. What can education learn from such games?

Think outside the box! Our children are growing up in a world in which it is common for teams of people, with members located throughout the world, to work together on complex problems and tasks. You have undoubtedly heard the African proverb, “It takes a whole village to raise a child.” Combine this idea with that of global village and you can see that nowadays, the whole world is involved in raising and educating our children. Our children need an education that prepares them to be effective participants in this global village.

**Puzzle Problems**

This book will expose you to a variety of games. One type of game is called a puzzle. 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 Rubrics cube provide good examples of this.

A child 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 of putting together a jigsaw puzzle.

Other types of puzzles require a broad and deep background. Contrast a jigsaw puzzle or a Rubric cube with a crossword puzzle from the New York Times newspaper. The crossword puzzle draws upon reading, spelling, word definitions, and word-suggestion clues.

In some cases, there will be a large number of variations on a particular type of puzzle. There are lots of different interlocking jigsaw puzzles, and there are lots of different crossword puzzles.

In other cases, a puzzle will be one-of-a-kind. Once you have figured out how to solve the puzzle, it is no longer a challenge. Here is an example of a brain-teaser puzzle that you may have seen before.

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

**Solution:** Take the chicken across the river first and leave it on the other side. Return to where you have left Wolf and the grain.

Next, take Wolf across the river, and leave him there, but bring the chicken back with you.

Next, leave the chicken where you started. Take the bag of grain across the river and leave it with Wolf.

Finally, go back and get the chicken, and take it with you across the river.

This brain teaser requires you to think outside the box. Many people do not think about the idea that in solving this puzzle you might bring something back on a return trip. They never consider this possibility, and they are unable to solve the puzzle problem.

Here is another brain-teaser puzzle that requires thinking outside the box.

**Problem:** Using pencil and paper, arrange nine distinct dots into a three by three pattern as illustrated in Figure 1.1. 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 1.1. 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 1.2. After studying this solution, you can easily find other 5-line line segment solutions.

```
  |
  |
  |
```

Figure 1.2. A 5-line segment solution for the 9-dots puzzle.

How can one possible complete the task with only four line segments? As with the river-crossing puzzle, it is necessary to think outside of the box. In this case, the layout of the puzzle tends to create a visual box. Many people do not think about drawing line segments that go outside of the visual box. A solution using four line segments is shown in Figure 1.3.

```
  
  
  
```

Figure 1.3. A 4-line segment solution for the 9-dots puzzle.

I suspect that most parents, teachers, and other adults really don’t care whether students learn how to solve this 9-dots, 4-line segment puzzle problem. I don’t ever recall encountering a similar real-world problem during my lifetime.

However, many people care about helping students learn to think outside the box. Thus, they want students to have an informal and formal educational system that will help students learn to think outside the box.

In this book, we will explore real-world problems and game-world problems. Of course, the games are part of our real world, so the distinction is somewhat silly. However, the goal in this book is to learn to make better use of the game world to learn about solving problems in the real world.
Thinking outside the box is illustrated by the two puzzles illustrated above. However, these two examples are useful in education mainly if the learner makes a connection between the examples and real-world problems. Young students will seldom make such connections on their own. Merely having students work to solve these two puzzles and then showing them solutions will not help the typical young student to make such connections.

This is where a teacher enters the picture. A good teacher can help students to 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, 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!

The chances are that you are like many other people, in that you have studied math for many years, starting in preschool or elementary school. Thus, you can probably tell me the difference between a dot and a mathematical point. A dot has size, while a point does not. The puzzle was stated in terms of using nine distinct dots (not nine points). A 3-line segment solution is illustrated in Figure 1.4. To make the illustration easier to understand, I have enlarged the dots in the puzzle.

![Figure 1.4. A 3-line segment solution for the 9-dots puzzle.](image)

This solution not only illustrates thinking outside the box, it also illustrates the importance of precise vocabulary and the problem solver understanding the meaning of the precise vocabulary. This is a tricky puzzle problem, because many people tend to think of a dot as a (mathematical) point.

Here is a final challenge. Can the problem be solved using only two line segments? Prove your assertion!

The request for a proof is, of course, a standard thing in mathematics courses. However, proof is an important concept in many other disciplines. A lawyer works to prove a client is not guilty, and a researcher in science works to prove a scientific theory. One way to prove that a problem can be solved is to actually solve it. Demonstrate to other people how to solve the problem, and do so in a manner so that they can also solve the problem. That is what I did in the 3-line segment solution to the 9-dots problem.

Suppose, however, you suspect that a problem does not have a solution. Then, your task becomes one of proving that the problem does not have a solution. Your proof must be convincing to other people. See if you can “prove” that the 9-dots puzzle problem cannot be solved using only two connected line segments.
I suspect that as you thought about this puzzle problem, you forgot about the possibility of the dot pattern being on a sphere. There was no explicit statement in the problem that the nine dots are in a plane. Part of thinking outside the box is to think critically and carefully. What do you actually know about the facts of the problem, and what do you make up in your mind? As you work to understand and create meaning in a problem, you may well think yourself into a box in which the problem cannot be solved.

**Problems and Problem Solving**

Puzzle problems are a type of problem. A great deal of this book is about problem solving and what we can learn about problem solving through studying and using games.

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 1.5 graphically represents the concept of problem solving. Usually 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.

![Figure 1.5. Problem-solving — how to achieve the final goal?](image)

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.
2. You have a clearly defined goal (a desired end situation). 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 applicable in helping you move from the given initial situation to the desired goal situation. There may be specified limitations on resources, such as rules, regulations, and guidelines for what you are allowed to do in attempting to solve a particular problem.
4. You have some ownership—you are committed to using some of your own resources, such as your knowledge, skills, and energies, to achieve the desired final goal.

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, you have an ill-defined problem situation (frequently called a problem situation or an ill-defined problem) rather than a well-defined problem. An important aspect of problem solving
is realizing when you are dealing with an ill-defined problem situation and working to transform it into a well-defined problem.

Consider some problem situations such as global warming, globalization of business, terrorism, homelessness, drugs, and the US scoring below some other countries in international tests. These are all problem situations because the givens, guidelines, and resources are not specified. You may or may not happen to care about specific problems that relate to these problem situations.

There is nothing in the definition of problem 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.

People are often confused by the resources (component 3) of the definition. Resources merely tell you what you are allowed to do and/or use in solving the problem. Indeed, often the specification of resources is implied rather than made explicit. Typically, you can draw on your full range of knowledge and skills while working to solve a problem. However, you are not allowed to cheat (for example, steal, copy other’s work, plagiarize). Some tests are open book, and others are closed book. Thus, an open book is a resource in solving some test problems, but is cheating (not allowed, a limitation on resources) in others.

People often have access to computers as they work to solve a problem. They draw upon both the capabilities of their mind/brain and of Information and Communication Technology (ICT) systems. They routinely make use of computational thinking (see the Preface) as an aid to problem solving.

Resources do not tell you how to solve a problem. For example, you want to create a nationwide ad campaign to increase the sales by at least 20% of a set of products that your company produces. The campaign is to be completed in three months, and it is not to exceed $40,000 in cost. Three months is a time resource and $40,000 is a money resource. You can use the resources in solving the problem, but the resources do not tell you how to solve the problem. Indeed, the problem might not be solvable. (Imagine an automobile manufacturer trying to produce a 20% increase in sales in three months, for $40,000!)

Problems do not exist in the abstract. They exist only when there is ownership. The owner might be a person, a group of people such as the students in a class, or it might be an organization or a country. A person may have ownership "assigned" by his/her supervisor in a company. That is, the company or the supervisor has ownership, and assigns it to an employee or group of employees.

The idea of ownership can be confusing. In this book, we are focusing on you, personally, having a problem—you, personally, have ownership. That is quite a bit different than saying that our educational system has a problem, our country has a problem, or each academic discipline addresses a certain category of problems that helps to define the discipline.

The idea of ownership is particularly important in teaching. If a student creates or helps create the problems to be solved, there is increased chance that the student will have ownership.
Such ownership contributes to intrinsic motivation—a willingness to commit one's time and energies to solving the problem. All teachers know that intrinsic motivation is a powerful aid to student learning and success.

The type of ownership that comes from a student developing or accepting a problem that he/she really wants to solve is quite a bit different from the type of ownership that often occurs in school settings. When faced by a problem presented/assigned by the teacher or the textbook, a student may well translate this into, "My problem is to do the assignment and get a good grade. I have little interest in the problem presented by the teacher or the textbook." A skilled teacher will help students to develop projects that contain challenging problems that the students really care about.

Now, what does this formal definition of problem have to do with thinking outside the box? Plenty! In a game setting, the rules and regulations are usually carefully stated. Even then, however, there may be exceptions that allow thinking outside the box thinking. The 9-dots puzzle certainly illustrates. Thinking outside the box and expanding the size of the dots, allowed us to see a 3-line solution. As you were working on the 2-line version of the puzzle, did it occur to you that perhaps the dots could overlap or that the dots could be on a sphere?

You know that students often develop personal interest in (ownership of) the problem of playing a game well. Now, if only such games had redeeming educational value … Wouldn’t it be nice if students spent time in an intrinsically motivated state, working to learn to solve problems that they have ownership of, but that also tie in well with the contents of the regular school curriculum? I wonder what school would be like if students spent much of their time in such an environment?

The steam engine existed a long time before the internal combustion engine was developed. Imagine being an inventor studying a steam engine, and thinking about how to make a smaller and more fuel-efficient engine. Perhaps the firebox could be made a little smaller and better insulated? Perhaps one could find a fuel that is more concentrated than coal or wood? Thinking outside the box led to using a fuel such as gasoline, and having the “fire” occur right next to the piston, inside the cylinder that contained the piston. What a marvelous example of thinking outside the box!

**Problem Solving is Part of Every Discipline**

In general terms, each discipline or domain of study can be defined by its unique combination of:

1. The types of problems, tasks, and activities it addresses.
2. Its tools, methodologies, and types of evidence and arguments used in solving problems, accomplishing tasks, and recording and sharing accumulated results.
3. Its accumulated accomplishments such as results, achievements, products, performances, scope, power, uses, impact on the societies of the world, and so on.
4. Its history, culture, unifying principles and standards of rigor, language (including notation and special vocabulary), and methods of teaching, learning, and assessment.
5. It particular sense of beauty and wonder. A mathematician’s idea of a “beautiful proof” is quite a bit different than an artist’s idea of a beautiful painting or a musician’s idea of a beautiful piece of music.

Each discipline has its own ideas as to what constitutes a problem to be solved or a task to be accomplished. The following list is not all-inclusive, but is intended to emphasize that we are interested in general ideas of problem solving in all disciplines. We are interested in:

- Question situations: recognizing, posing, clarifying, and answering questions.
- Problem situations: recognizing, posing, clarifying, and solving problems.
- Task situations: recognizing, posing, clarifying, and accomplishing tasks.
- Decision situations: recognizing, posing, clarifying, and making decisions.
- Using higher-order, critical, creative, and wise thinking to do all of the above. Often the “results” are shared or demonstrated as a product, performance, or presentation.
- Using tools that aid and extend one’s physical and mental capabilities to do all of the above. Examples of such tools include reading, writing, math, and computers.

Throughout this book we will be discovering and exploring various strategies for problem solving. The single most important strategy for problem solving is building upon the previous work of yourself and others. In this book, we will call this the build on previous work strategy. You may prefer to call it the look it up strategy. The development of the Internet and the Web have made it much easier to retrieve information from libraries and from other people. Moreover, tens of thousands of computer programs have been written so that computers can directly solve or help to solve many of the problems that people want to solve.

**Cognitive Maturity**

You make routine use of a number of different problem-solving strategies without giving much thought to them. As an example, often when you are about to make a decision, you think about the consequences of this decision. You mentally “play out” what might happen in the future if you make a particular decision or take a particular action. If you are impulsive—perhaps often acting without thinking of the consequences—you work to overcome this impulsiveness.

You have had years of informal and formal education in this think before your act strategy. It is now a well ingrained component of your cognitive maturity. As a parent or teacher, you undoubtedly place considerable emphasis on helping children make progress in this aspect of cognitive maturity.

Another good example is the set of strategies you bring to bear when faced by a challenging learning task. You know a great deal about yourself as a learner. You can self-assess your progress in learning. You can set standards based on how well you have done other learning tasks. Your strategies in dealing with a challenging learning task are an important aspect of your current level of cognitive maturity. You certainly want to help children make progress in learning and using their own set of strategies in this area.

Notice that these aspects of cognitive maturity are not dependent on having learned any specific discipline. Cognitive maturity is a component of every discipline, and it cuts across all disciplines. Games can be used to help create an environment in which children can increase
their levels of cognitive maturity. It is easy to see how an adult who has a higher level of

cognitive maturity than a student can serve as a teacher and mentor in helping a student increase

in cognitive maturity.

**George Polya’s General Problem-Solving Strategy**

George Polya was a great mathematicians and teacher of the 20th century. He wrote

extensively about problem solving. Polya's six-step problem-solving strategy is useful in math

and in most other disciplines. The following version of this strategy has been modified to be

applicable in many different domains. All students can benefit from learning and understanding

this strategy and practicing its use over a wide range of problems.

1. Understand the problem. Among other things, this includes working toward

having a clearly defined problem. You need an initial understanding of the

Givens, Resources, and Goal. This requires knowledge of the domain(s) of

the problem, which could well be interdisciplinary.

2. Determine a plan of action. This is a thinking activity. What strategies will

you apply? What resources will you use, how will you use them, 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. Place 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 because of this thinking.

4. Carry out your plan of action. Do so 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 expertise.

5. Check to see if the desired goal has been achieved by carrying out your plan

of action. 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 to 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. (Work to increase your reflective intelligence!)
Modeling and Simulation

When you were a child, you may well have built and/or played with model cards, model airplanes, and model people (such as toy figures). A model car has some of the characteristics of a “real” car.

Models have long been used as an aid to representing and solving problems. For example, when the Wright brothers were in the process of developing their first airplane, they developed models of components of their airplane (such as a wing) and tested them in a wind tunnel they built.

The development and use of computer-based models adds a valuable new addition to use of models to help solve problems. A computer model of a car or an airplane can be tested in a virtual wind tunnel (that is, in a computer model of a wind tunnel). In biology, chemistry, physics and other sciences, computer modeling and then running simulations using the models has become a routine aid to research. Indeed, the three standard approaches to research in science are now experimental, theoretical, and computational. The term computational in this case means computer modeling and simulation.

Computational thinking includes thinking in terms of computer modeling and simulation. It also includes thinking in terms of mental modeling and simulation. When you are mentally considering the possible results of various decisions you might make, you are doing mental modeling. That is, you are doing a form of computational thinking.

Spreadsheet software was originally designed for modeling and simulation in business. A spreadsheet model was designed to represent a certain part of a business, such as inventory. What If” types of questions could be answered by running the model (that is, doing a computer simulation based on the model) to help answer questions. Spreadsheet models are now a routine tool in business and a number of other fields.

How does this fit in with games? A game can be thought of as a model. Let’s take Monopoly as an example. In this game, one buys and sells property, invests in houses and hotels on a property, and travels around the game board. Movement is determined by rolling a pair of dice, and various random events occur when your playing piece lands on certain board locations.

The game and its rules can be thought of as a model; playing the game is doing a simulation based on the model. Now, let’s carry this one step further. While Monopoly was originally developed as a physical board game, it now also exists in a computerized form. Many people now play Monopoly using a computer model of the original game.

There are many advantages of computer models. In a game setting, the computer system can help take care of many of the details of playing the game. For example, instead of using physical dice, playing pieces, money, and so on, one uses computer representations (a virtual board, virtual playing pieces, virtual money) to play the game. Thus, none of these objects get worn out, damaged, or lost.

A second advantage of the computer model/simulation is that rules are strictly enforced. A player cannot “accidentally” move one space too far or pay less than the required rent.

A third advantage of computer models is in the easy setup and take down of a game. The computer does this for the players.
There are other advantages. Here is a quote from http://www.download-free-games.com/board_game_download/monopoly3.htm, a Website that sells a computerized version of Monopoly.

Monopoly 3 is an exact replica of the traditional board game—only better! Animated tokens and property auctions, talking game announcer, the ability to customize rules and game boards, and online play all improve the classic game to make it even more fun than before.

For additional challenge, choose from 3 different skill levels when playing [against] the computer. Have you always played with a cash bonus on the free parking space? No problem! Just create your own customized rule and you can play Monopoly the way you always have. Overall, Monopoly 3 is a great game for the entire family.

You know, of course, that Monopoly is a game for two or more players. Notice that with the software described above, your opponents can be virtual opponents (the computer plays these roles). Similar types of advantages hold for computerized versions of many traditional games.

Many computerized games have another provision that allows the player to take back or undo a move. For example, suppose that you are playing some version of a solitaire card game on a computer. The computer quickly shuffles the deck and lays out the cards. As you make your moves, you can easily undo a move or a sequence of moves. Indeed, provision is usually made so that a single keystroke allows the player to start over, using the same initial card layout.

Computer modeling and simulation is now one of the most important aids to problem solving. You and your students can learn about uses of this strategy through playing and studying games.

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.

Millions of people in this country are addicts. Types of addiction include heroin, morphine, amphetamines, tranquilizers, cocaine, alcohol, nicotine, and caffeine. Other addictions include work, shoplifting, gambling, computers, and games.

Games? When I was in graduate school, one of my friends flunked out of a Physics doctoral program because he was addicted to 2-deck games of solitaire. Some of these 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 through playing such games. The immediate mental stimulation (the flow of dopamine and other endorphins) can be exhilarating. My friend found that such immediately available rewards overwhelmed the feelings of satisfaction gained through doing physics homework problems and attending physics classes and labs.

I could provide some personal testimonial of addictive qualities of computer games—but I won’t. Interestingly, I find that deep engagement in computer programming or in developing a spreadsheet has—for me—the same characteristics as game playing. For me, games, computer programming, spreadsheets and—sometimes—writing are all environments in which can immerse myself, finding deep satisfaction in using my creativity and brain power. I experience what Mihaly Csikszentmihalyi calls flow.
Mihaly Csikszentmihalyi is a world expert and leader in Flow Theory. See http://www.brainchannels.com/thinker/mihaly.html. Quoting from that Website:

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.

Here are two examples “outside the box” thinking related to addiction.

1. All children growing up in our world will encounter numerous addictive or addictive-like drugs, opportunities, and situations. Part of a good formal and/or informal education is to learn about how to deal with these situations. For some people, games are sufficiently addictive, or addictive-like, so they provide an opportunity to study themselves in an addictive-like setting.

2. For many students, games are intrinsically motivating. Motivation—or the lack thereof—is a very important aspect of 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.

Quoting James 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.

... The answer that is interesting is this: the designers of many good games have hit on profoundly good methods of getting people to learn and to enjoy learning. Furthermore, it turns out that these methods are similar in many respects to cutting-edge principles being discovered in research on human learning.

Final Remarks

Games are a form of play. However, games provide an environment in which game players can learn about themselves. Games provide an environment in which one can interact with other people and develop certain types of social skills. Games provide an environment in which one can develop a variety of thinking and problem-solving skills that are useful in both non-game and game environments. Games provide an environment in which one can gain in mental maturity.
Many games have very long histories. Games that have survived over the years tend to have characteristics that fit well with the needs and interests of children and adults. Well before the advent of computers, many games had addictive-like qualities for some game players.

Computers have added new dimensions to games, and have provided more opportunities for a person to develop an addictive-like dependency on games. At the same time, computers are making possible games that have considerable educational value. The attention grabbing and attention holding characteristics of many of today’s computer-based games are a challenge to our traditional formal educational system. At the same time, such games provide an opportunity for some changes that have the opportunity to improve our educational systems.

I recently used the quoted expression “thinking outside the box” as a search term in Google. I got over 1,700,000 hits. It is clear that many people think about and write about thinking outside the box. However, our educational system experiences only limited success in developing this type of thinking in students. There is substantial room for improvement.

Activities for the Reader

This section contains some questions and activities for the person reading this book. Some are designed for people who are taking a workshop or course using materials from this book. The individual reader working alone may also find many of the questions and activities to be useful.

1. Think of some personal, real-world examples in which you thought outside the box. This book is one of my personal examples. Since I was a young child, I have played games for entertainment. Only recently, I have thought outside the box and begun to explore possible educational values of the games I played as a child.

2. Create a 16-dot (4 by 4 grid) puzzle problem akin to the 9-dot puzzle. Pose various goals associated and see if you can achieve these problem-solving goals. Many people enjoy creating puzzle problems and games. This is a different type of intellectual challenge than merely solving puzzles and playing games created by others. In the real world outside of games, problem posing (that is creating or defining problems) is an important component of each discipline of study.

3. Have you experienced flow, as described by Mihaly Csikszentmihalyi? If so, describe situations in which you have experienced flow and give your personal opinions on how this topic might fit in with informal or formal education. If you think that you have never experienced flow, then do some reading about Runner’s High and discuss how it might relate to flow. See, for example, http://www.lehigh.edu/~dmd1/sarah.html.

4. Consider the following quotation:

   Comments from a student panel that my school district organized to investigate grading practices further elucidated the problem. Students reported that they see their schoolwork as a game they play for grades—a game that at best treats learning as an incidental, and at worst distracts students from making meaning. One student referred to this grade game as academic bulimia: Students stuff themselves with information only to regurgitate it for the test, with little opportunity for any thoughtful engagement that would produce deep understanding and

Compare and contrast use of the term *game* in the quotation with the types of games and educational uses of games being discussed in this book.

5. Do some research on the topic *thinking outside the box.* Develop some ideas on how to improve your own ability to think outside the box, and how to improve the ability of students to do so.

**Activities for use with Students**

This section contains some ideas for use with students. It is assumed that the teacher, parent, or other person making use of these suggestions will adjust the activities to fit the needs of the students.

1. What are some games that today’s students find to be fun to play? Engage an individual student or a group of students in a brainstorming activity designed to make a long list of games that they have played and enjoyed. As the list is being created, divide its items into three categories:
   a. Board games, card games, and other types of non-electronic games that are not physical sports games.
   b. Electronic games.
   c. Physical sports games
   d. Other (not fitting easily into any of the above categories.

   Use this activity to promote a discussion about whether a game can fit into more than one category, what is a game, is a puzzle a game, what makes a game fun, can a game be fun for one person and not for another, and so on.

2. Engage students in a discussion about what they have learned and other ways in which they have benefited by playing the various types of games from the list developed in (1).

3. Have each student select a game that they have played, and suggest some changes in the game that would make it more fun, or a better social experience, or a better learning experience. Encourage students to think outside the box. For example, is a game such as Monopoly more or less fun if one roles one die instead of a pair of die in making a move. How about rolling three dice to make a move? How about rolling three dice and selecting the two that add to the smaller total, and that is one’s move. How about using a 12-sided die (is there such a thing)?

4. Lead your students in a brainstorming session about what it might mean to think outside the box. After your students reach a reasonable level of agreement on what this term means, engage them discussing the extent to which schools and parents place a lot of emphasis on thinking inside the box.
5. Talk with your students about cognitive maturity. Help them to develop examples in which one makes use of their cognitive maturity. Do whole class brainstorming on ways to increase one’s level of cognitive maturity.