1

Play the Whole Game

YOU KNOW HOW MOUNTAINS ON THE HORIZON CAN LOOK SMALL, BUT WHEN you actually approach them they turn out to be much higher? This was my experience as a doctoral student approaching a dissertation. From a distance, the mountain did not seem so formidable, but when I got to the base I had no idea how to climb it.

My academic degrees are from the Massachusetts Institute of Technology. I was a mathematics major. After I finished the undergraduate work, I continued into a doctoral program, developing an interest in mathematical approaches to artificial intelligence. Artificial intelligence is the study of how to get computers to undertake intelligent activities, such as playing chess or proving mathematical theorems or controlling a robot to do interesting and challenging things. My work on artificial intelligence stimulated my interest in thinking and learning in human beings. After finishing my degree, I slid over into the world of cognitive psychology and education, but the why of that is another story. Right now, you can picture me in the foothills of the dissertation range, thinking about what kind of research on artificial intelligence to attempt.

The problem was *problem finding.* There is a very useful rough distinction between problem solving and problem finding. Problem solving is the art and craft of dealing well with problems that are already reasonably clear. Sometimes we find such problems in a book.

Sometimes they emerge as blatant needs in the course of everyday life. Wherever they came from, there they are, and we burrow into them and try to dig through them. Just because they are clear in outline does not make them easy. For instance, the problem of lighting efficiently with electricity had been recognized for some time and pursued by a number of inventors, before Thomas Edison finally cracked it. Classic mathematical conjectures like Fermat's Last Theorem not uncommonly linger for centuries in very well-defined form before anyone resolves them.

Problem finding is a somewhat different matter. Problem finding concerns figuring out what the problems are in the first place. It also involves coming to good formulations of problems, formulations that make them approachable. Often it also involves redefining a problem halfway through trying to solve it, out of the suspicion that one may not be working on quite the right problem.

So my dissertation problem was problem finding. I really did not know how to go about looking for a good topic. I was very able and even creative at problem solving, with a good toolkit of technical knowledge, but problem finding was another face of the game.

I wondered, why the mountain? I thought over my undergraduate and graduate experience at MIT and realized something that surprised me at the time and has stayed with me ever since: In my technical courses, I had rarely done anything but *solve* problems. I almost always succeeded, but the problems came from the text or the instructors. I had never undertaken anything like a project or an open-ended investigation. The consequence was inevitable: I had a fierce battery of problem-solving skills and hardly any problem-finding skills.

My experience in the humanities was quite different. Contrary to what you might think for a technical school, MIT had very strong offerings in literature, philosophy, music, and other areas, as well as notable professors. I nourished a range of interests in the humanities and took a variety of courses. There, I realized, problem finding was routine. The major piece of work for a course was normally an essay or two, with great latitude about their topics. I routinely had to ask what sorts of questions were worth pursuit, whether I could assemble a good argument, where to find relevant resources, and how to bundle it all together into a compelling statement.

Let me be clear here: MIT gave me an excellent undergraduate and graduate education. The institution treated me generously with support and flexibility. It was a privilege to be there and I learned a great deal that proved both interesting and helpful ever since. I'm just pointing to this one puzzle, problem solving versus problem finding.

It's a puzzle of playing the whole game. Problem finding, after all, is part of the whole game. Look at any piece of formal instruction you want, any subject matter, any age. Apply this simple test: If there's no problem finding in sight, you can be sure that the learners are not playing the whole game.

The Quest for the Whole Game

When I think about what it looks like for learners to play the whole game, I think of teachers I know who have made whole games one of their teaching strategies. I think of how they invent and adapt whole games creatively in the service of their students' learning. One such person was Lois Hetland, now a professor and research colleague, but several years ago a seventh-grade teacher participating in a research and development project on teaching for understanding. (I'll say more about the teaching for understanding framework later in this chapter and in the chapters to come.)

Lois was teaching an integrated humanities strand that focused on colonial America. She organized the students' work around several fundamental questions that the class lived with throughout the year. Some of the questions focused on the role of land: How does land shape human culture? How do people think about the land? How do people change the land? Other questions probed the tricky issue of historical truth: How do we find out the truth about things that happened long ago or far away? How do we see through bias in sources?

Lois Hetland called all these questions *throughlines,* an allusion to a notion from the method acting school of Constantin Stanislavsky.

By throughlines he meant central themes threading through the entire course of a play. Lois Hetland made a point of bringing the class back to these throughlines no matter what the particular topic under consideration. The aim was a deeper understanding of colonial America, but more than that some insight into the character and rhythm of inquiry and students' management of their own learning.

With the same teaching for understanding project in mind, I also think of Joan Soble, a talented English teacher at Cambridge Rindge and Latin High School. Joan wondered what to do for a group of ninth graders considered at risk and as she put it, "perpetually overwhelmed" by the demands of schooling. She designed an introductory writing course for them. The course experience involved various activities, among them preparation for writing by laying out collages, maintaining and reviewing portfolios with a critical eye, and articulating and pursuing individual goals. In focusing on their individual goals, the students were aided by a form targeting various writing skills they might want to sharpen, in other words, working on the hard parts. The skills ranged from sentence structure to ways of revising to strategies for managing their own work patterns better.

Readers might recall my MIT experience at this point and speculate that whole games are much easier to put together in the humanities than in mathematics and science. Yet examples are easy enough to find in these disciplines as well. Chris Dede, a fellow professor at the Harvard Graduate School of Education, sustains a line of research and development work on the scientific method and how to get students doing it as well as learning about it. He and his colleagues have constructed a MUVE called River City. MUVE stands for multi-user virtual environment. Many popular games that adolescents and young adults play online have this characteristic; participants navigate through virtual worlds, represented by icons called avatars, encountering and interacting with other players who may be physically located in Beijing or Cape Town or Rio.

In the River City MUVE, the students face a problem. Diseases of various sorts are sweeping through the virtual population. What are the causes? Exploring River City, the students can observe at various sites, test the water, and in other ways investigate the possible sources of the epidemics. In doing so, they learn some science content, and they also engage in the process of scientific inquiry itself.

Or turning to mathematics, there is an example from Kenna Barger of Elkins, West Virginia, one of the recipients of Disney's 2001 American Teacher Awards. An excellent vignette of her teaching ninth-grade algebra can be found on a videodisc developed by my colleague Ron Ritchhart about the nature of creative teaching. She leads the students in water balloon bungee jumping, the outlines of which were developed by a program at the University of Arizona called M-PACT, learning Mathematics with Purpose, Application, Context, and Technology.

Water balloon bungee jumping is a complete exercise in mathematical modeling. The ninth-grade students have been studying linear equations. They start the activity by forming small teams and measuring the stretchiness of rubber bands with weights attached to them. The teams use their algebra to construct a model of how much weight produces how much stretch. The activity is anything but routine and formulaic. The students struggle with issues about what counts as dependent versus independent variables and how to represent the situation, while Kenna Barger circulates and coaches.

Then the entire class troops outside. The teams in turn drop water balloons attached to rubber bands from the roof of the school—this is the water balloon bungee jumping part. The students have used their equations to predict just how much elastic would bring their balloon to just above the ground. A student on a team often lies underneath the descending balloon. The challenge is to come as close as possible without breaking the balloon on the ground . . . or the student. The entire exercise involves joining experiment with mathematical modeling using linear equations to try to understand how the whole system works and make effective predictions.

Barger emphasizes that this is only one piece of a year-long effort to teach algebra, seeing it not just as an abstract system of manipulating symbols but as a process of mathematical modeling. Barger comments, "When I was a student, I was always the annoying one in the back of the classroom who kept asking 'Why?' It was not until I began teaching at a school that emphasizes real-world careers and collaboration among faculty and disciplines that I truly got this question answered."

Such examples are not hard to come by. Many others can be found on the DVD with the Barger example, or in the book *Teaching for Understanding,* or in endless other resources available to the educational community. What then are the earmarks of playing the whole game? How do we know whether we've got a whole game or not?

In settings of learning, a whole game is generally some kind of inquiry or performance in a broad sense. It involves problem solving, explanation, argument, evidence, strategy, skill, craft. Often something gets created—a solution, an image, a story, an essay, a model. Moreover . . .

It's never just about content. Learners are trying to get better at doing something. Joan Soble's students are trying to get better at writing. Lois Hetland's students are trying to get better at understanding colonial America and at historical inquiry. Kenna Barger's students are trying to get better at mathematical modeling.

It's never just routine. It requires thinking with what you know and pushing further. Rather than just standard routine problems, it involves open-ended or ill-structured problems. The writing, rethinking the throughlines again and again, modeling the fall of the water balloons, all of these endeavors asked the learners to go beyond what they already knew and extrapolate to novel and puzzling situations.

It's never just problem solving. It involves problem finding. Students in Joan Soble's writing course set their own goals. In the colonial America course, Lois Hetland expected her students to help her sharpen and interpret the throughlines in the context of new topics. Kenna Barger's water balloon project was perhaps the most defined, but even there the circumstances allowed for a number of different approaches.

It's not just about right answers. It involves explanation and justification. The learners in all the settings have had to explain and justify what they were up to and how they came to the places that they have.

It's not emotionally flat. It involves curiosity, discovery, creativity, camaraderie. Kenna Barger's students competed in a good-natured way on the water balloon task and strove to get those linear equations to do something. Joan Soble's students got into writing and aspired to do better. Lois Hetland's students found their curiosity about colonial America provoked again and again. They were not just learning but developing dispositions to learn, like curiosity and persistence. Of course, not every learner is going to be interested in everything, but the conditions favor most students getting somewhat interested (more about this in Chapter 2).

It's not in a vacuum. It involves the methods, purposes, and forms of one or more disciplines or other areas, situated in a social context. Joan Soble's students dealt with the methods, purposes, and forms of writing in collaborative ways. Lois Hetland's students dealt with the methods and purposes of historical inquiry, framing their conversations and their writing with appropriate forms of justification and explanation. Kenna Barger's students worked in teams to deal with mathematical formalisms and experimentation.

These are the earmarks of a whole game, but they can also serve as guidelines for constructing a whole game. Start anywhere you want, say, with the routines of fractions arithmetic or a couple of rules of grammar. No whole game in sight yet, but some questions lead in the right direction. Ask: What would this topic be like if it's not just about content, but learners are trying to get better at doing something? What would they be getting better at doing? Ask: What would the topic be like if it were not just routine, if it required thinking with what you know and pushing that further? Ask: If there were some problem finding involved, where would it figure? Every answer to questions like these draws a larger circle around an initially limited topic. As the circle widens it's not hard to arrive at some reasonable picture of the whole game.

Kinds of Whole Games

Of course, there is more than one good answer, more than one good version of a whole game. There are many games of thoughtful inquiry around history, for example. Learners can look carefully at original sources to form conjectures and seek evidence for them. Learners can compare and contrast alternative historical accounts, even textbooks from different countries, to discover commonalities and contrasts and consider whether the contrasts reflect biases. Learners can examine pivotal events like Caesar's ascent to power in Rome, or they can look at the characteristics of everyday Roman life in the time of Caesar. Learners can compare power grabs then and now, or everyday life then and now.

While the "games" here are not as neatly defined as baseball or chess, there is no need for them to be. Realistically, any discipline brings a diffuse cloud of practices into play. Sometimes professionals even debate which ones are right and proper—the right way to do history or economics or literary analysis—but we don't have to worry about that. The challenge of *play the whole game* is not to find the one right official canonical version, but to get some reasonable version into action. Chapter 5, "Uncover the Hidden Game," will have more to say about patterns of disciplinary thinking.

Sometimes the game is integrative. It cuts across a range of disciplines, weaving together ideas from several. A class project might involve an ecological survey of the community, in the process applying concepts from biology, using mathematics to chart problems and trends, and exercising skills of reading and writing to synthesize results and propose a community action plan. A group investigation might focus on the use of art for political purposes, studying several positive and negative cases (for example, protest art in South Africa, Nazi propaganda), considering literary and aesthetic values, identifying political manipulation, and estimating with statistics how much exposure and impact was achieved.

Community ecology surveys and group investigations of political art are examples of what might be called project-based learning, one of several ways to organize learning in a holistic way. Numerous examples of project-based learning are available. For one source, the *Edutopia* Web site, maintained by the George Lucas Educational Foundation, offers a sizable collection with brief video examples.

Project-based learning by definition involves *big* wholes that take some time to work through. But a whole game need not be a big game!

This is important to recognize, because big games do not fit very well in some educational settings with their schedules and mandates. However, there is always some room for small games, and learning by wholes can proceed quite briskly in the small. Looking at a poem or a work of art or a newspaper editorial, reflecting on it, and discussing it is an entire meaningful activity that might fit in half an hour.

Also whole games often are not played all at once anyway, but spread out over time. Lois Hetland's students visit their throughlines again and again, pursuing the same questions in greater depth. Students trying to figure out the sources of disease in the online River City environment enter multiple times.

Some other familiar practices with a whole-game spin include problem-based learning, case-based learning or the case study method, community action initiatives, role-playing scenarios, formal debate, and studio learning (see Chapter 6). These each have their own flavor, but they are hardly perfectly distinct. Often the same example can be used to illustrate two or three of these practices. Here I'll just touch on three more.

Role-playing scenarios, which also can be relatively brief, are a good way to develop perspective and open-mindedness in an area. You may think you know what your core values are and what you would do if you were running the company or running the state. However, learners are often surprised by their new attitudes when they are put in role-playing scenarios where now they occupy such positions. Mindsets are not just the products of the values we hold but the roles we play.

In problem-based learning, students in small groups tackle problems together. An episode can take a class period or much longer, depending on the scope of the problem. The problems are deliberately somewhat messy. Generally they lack perfect answers and the learners need to seek information, not just work with what is given. Teachers facilitate the process. Such previous examples as water balloon bungee jumping and River City can be seen as problem-based learning.

The Jasper Woodbury series on mathematical problem solving, developed by the Learning Technology Center of Vanderbilt University, is one version of problem-based learning. The approach uses *anchored instruction,* providing a vivid scenario, the "anchor," that can be brought into the classroom as the setting for the problem. The Jasper Woodbury series centers on a dozen videos featuring the lead character Jasper Woodbury as he deals with various situations that require mathematical reasoning.

For instance, in the first video of the series, students watch Jasper as he takes his boat upriver to inspect and ultimately purchase a new, larger boat. Then Jasper has to figure out whether he can cruise the new boat back to his home wharf before sundown, because its night running lights do not work. The students address the problem. They have to consider when sundown comes, distance, gasoline consumption, whether a single tank of gas will do it, where Jasper might get more gas if not, and other factors, including some missing information that must be guessed at. Relevant information appears at incidental moments throughout the video, in passing comments, on riverside signs, in newsprint, mixed naturalistically with irrelevant information. Students typically work in small groups and hop around in the video to hunt for needed facts. Research shows that the Jasper Woodbury adventures improve learners' flexibility as mathematical problem solvers.

Another common application of problem-based learning is medical education, where, instead of sitting through extended lectures on anatomy and physiology, doctors-to-be work in small groups on simulated cases representing maladies they do not know that much about yet. Here are the initial symptoms. What do you think might be going on? Where would you need to look to find out? What anatomy and physiology do you need to know and understand? Let's divide up our questions, find out some answers, and teach them to one another. Then let's generate a trial diagnosis and find ways to test it further. Problem-based learning is more likely than technical lectures to cultivate diagnostic reasoning based on the active use of knowledge.

Continuing for a moment at the university level, problem-based learning in this style can also be viewed as a kind of case-based learning. David Garvin, professor at the Harvard Business School, does just that in a comparison of the use of the case method at three Harvard professional schools—the medical school, the law school, and the business school. Garvin emphasizes how each setting has cultivated its own distinctive version of the case method. Medical students focus on the diagnostic process in small groups that run themselves with some help. Law students work alone for the most part and convene in large classes. Their professors call upon students randomly for the facts and issues of a case and develop whole-class discussions. The students do not address one another; most of the direct interaction occurs between students and the professor. The focus falls on critical features of the case and how small differences can have large legal ramifications.

At the business school, students prepare individually or often in study groups for participation in whole-class sessions. Business cases typically pose problematic situations and ask for next steps: If you were the boss what would you do? Students need to back their ideas with detailed analyses and arguments. The first student to speak—called upon out of the blue or at best warned a few minutes earlier—will often address the class for five or ten minutes.

Garvin notes the limits as well as the qualities of these three different versions of the case method and logs how deliberations at the three professional schools are striving to improve them. What the three share is their quest to involve learners in kinds of reasoning appropriate to their professions: medical diagnosis, discerning the legal implications of features of cases, responding to business problems with well-grounded decisions and plans.

I hope this quick review shows clearly that there are many variations of learning with a whole-game flavor, some with names—problem-based learning, case-based learning, and so on—and some simply patterns of activity that ingenious teachers have assembled. Most of them can appear in longer or shorter versions. Therefore, learning by wholes might seem straightforward. With no lack of approaches, just pick one and run with it.

Not so fast! As the saying goes, the devil is in the details. Any of these practices draw learners into something like a whole game. However . . .

It's not just the form, it's the content and thinking. When you decide upon, say, problem-based learning, you have only just begun. What problems? What content and skills are they meant to cultivate? What kinds of thinking are they meant to foster—sifting historical evidence, detecting causal influences, adopting different perspectives? The general idea of problem-based learning or any of the other types says nothing about such matters. The principal challenge of constructing a whole game is not one of choosing a framework like problem-based learning, but filling the framework with an insightful conception of the game.

Also, *it's not just playing the whole game, it's the other six principles.* One can have much better or much worse versions of problem-based learning, project-based learning, or any of them. What's done to *make the game worth playing*? Are the *hard parts* somehow isolated for focused attention and then reintegrated? How is *play out of town* attended to, encouraging transfer of learning? What are the moves that *uncover the hidden game*?

And finally, *it's not just—or even particularly—discovery learning.* A casual read might suggest that across these practices learners engage in relatively free-form open-ended inquiry. Not so! These patterns of participation in learning are generally quite structured. They often involve considerable up-front information, for instance, the written or multimedia business cases that business students pore over to prep. They incorporate expected rhythms of interaction, who talks to whom and when, and stages of development: What happens first, what happens next, and what happens toward the end? A body of research summarized by Paul Kirschner, John Sweller, and Richard Clark warns that free-form practices do not work very well for beginners in a domain. Some versions of problem-based learning, project-based learning, and so on can be too loose, especially as learners get started. The learners need clear, worked-out examples and strong guidance, gradually faded back.

The point of learning through whole games is not to liberate learners from textbooks and engage them in personal exploration. The point of whole games is that they involve students in what we really want them to get better at. But of course even at the university level beginners cannot start in hospitals, courtrooms, or boardrooms. At an earlier age, beginners working at making sense of the daily paper or

The Catcher in the Rye or pollution in the local river cannot begin with erudite essays and statistical analyses. So where can they began? This brings us to the challenge of the junior version.

The Quest for the Junior Game

Students exploring Chris Dede's MUVE are not looking for real germs and toxins. Kenna Barger's students are not launching rockets from Cape Canaveral. Lois Hetland's students are not sifting through historical archives for original documents from colonial America. Joan Soble's students are not writing articles for *The Atlantic* magazine. They are not playing real baseball so to speak, not the full nine innings, not with nine on the team, not the regulation rules.

The relationship between their endeavors and the real thing is something like the relationship between backyard baseball and full-scale baseball. The junior version is less technically demanding. The timelines are much shorter. The activity often substitutes simulations for the real thing, for instance, simulated case documentation or a whole simulated environment like the MUVE or looking at reprints of historical documents. However, these junior versions capture a range of basic structural features of the full-scale game. They demand inquiry, problem finding, justification, explanation, indeed, the full range of earmarks listed earlier.

Junior versions are the key to making learning by wholes practical and powerful. Remember from the previous chapter how education always faces the fundamental problem of approaching complexity. Every teacher, every textbook, every parent, every coach has to find ways to cope with this problem. The more straightforward solutions are elements-first and teaching-about, but these tend to degenerate into *elementitis* and *aboutitis*.

The better solution is junior versions, better because junior versions involve learners meaningfully in whole games from the beginning and situate bits and pieces meaningfully in a bigger picture. Ideally junior versions provide students with what the Introduction called *threshold experiences,* experiences that usher them into new worlds of baseball, historical inquiry, writing, mathematical modeling, or whatever. I adapted the idea of threshold experiences from a very interesting body of work focused on university-level learning. Initially developed by Ray Land and Jan Meyer, the work foregrounds the idea of threshold *concepts.* These are key concepts that, once understood, bring learners to a deeper and broader sense of a discipline. In the context of learning by wholes, I'd like to emphasize not just threshold concepts but also threshold experiences.

Choosing a good junior version for beginners is an art that Joan Soble, Lois Hetland, Chris Dede, Kenna Barger, and many other teachers, mentors, parents, and others involved in education formal and informal embrace with care and commitment. Part of the art is throwing out what is not so important yet, while leaving the general spirit and shape of the game intact. Part of the art is substitution, for instance, swapping in simulations like the MUVE and replicas of historical documents. Part of the art is simply maintaining a reasonable level of challenge, not tossing beginners in with the experts. The game may be roughly the same in its rules—people don't normally learn to play checkers on a shrunk-down 4 × 4 board—but the level of play is approachable. Game makers themselves have embraced this principle, as evidenced by junior versions of popular board games such as Monopoly Junior, Junior Scrabble, and Clue Junior.

In the quest for a good junior game, the mix of throwing out and swapping in and maintaining a reasonable level of challenge reflects not only convenience, but the teacher's sense of what the learner already knows and therefore what will prove to be an accessible next step. This requires attention not just to what individual students are supposed to have learned considering their age and history, but what they have actually learned and how agile they are as learners, leading into the many practices of differentiated instruction. Learning by wholes helps by providing latitude: There are many different ways and levels through which learners can engage in a whole game.

Prior knowledge is the platform on which learners build. It wouldn't make a lot of sense to ask youngsters to become thoughtful strategic readers when they are struggling with decoding. It wouldn't make a lot of sense to involve youngsters in mathematical modeling with linear equations when they hardly know what linear equations are. So what is one to do?

The commonplace solution is elements first. Instead, learning by wholes suggests rethinking what junior game the learners might be ready for. Children struggling with decoding may not be ready to read texts strategically, but they can begin with thoughtful strategic *listening* as they are read to. Students just beginning algebra can build simple models of situations that interest them with tables and graphs and basic formulas. How does peak daily power usage vary with peak daily temperature? According to consumer data, how much does a small raise in price reduce sales? Is this the same percentagewise for inexpensive and expensive items? What's the relation between bird size and average migration distance for migratory birds? Problem finding comes into play here when students start with questions like these and figure out how to operationalize them—or formulate their own questions altogether.

If the lack of constituent skills gets in the way of using the obvious junior game, don't give up and settle for *elementitis.* Get even more junior! This does not mean stopping work on elements of decoding or algebra or any other constituent skill. Rather, such activities become more meaningful when seen as contributing to the next stages of the evolving whole game.

Related to what learners already know is the question of developmental readiness. Here again as in the Introduction I'm going to resist any plunge into the details of particular developmental theories and practices. For one thing, it is a whole world in itself with many resources available to educators. For another, again and again teachers and investigators have found that categorical statements about what children of various ages can and cannot do are risky. Children often display more skill and insight than expected if only the task is posed in the right way, with familiar materials, avoiding language that they might misunderstand, and providing tips and hints. Much depends upon the choice of a good junior version! Developmental themes will resurface when Chapter 5 explores uncovering the hidden game. For now, it's sufficient to urge a broad experience-based awareness of what happens to knowledge, understanding, and self-awareness as children advance from kindergarten through high school and beyond.

The reality is that when you devise a junior version of the game, you make your best-informed guess as to what learners already know and their developmental level. You produce a junior version and try it out to discover where it is too difficult, too easy, or just right. The first time around involves at least as much learning for you as it does for the learners, because you are always wrong in some ways. This is certainly my experience as an educator. Only over two or three cycles of working with real learners in real situations can we expect to home in on truly well-calibrated junior versions.

But what if there just is no junior version? What if the best one can do is elements first, until the learners have a critical mass of elements? In fact, aren't many things really like that?

For instance, you might suppose that swimming is a good example. Hardly anyone jumps in the lake and swims, not even awkwardly and haltingly. The way I learned to swim, the way most anyone learns to swim, seems to be elements first, standing on your feet up to your waist in the water, bending over, face immersed, turning your head sideways to practice breathing, practicing the stroke. Or holding onto a bar and practicing various kicks. Or supported by water wings.

However, the conventional teaching of swimming is not as elements first as it appears. First and most important, children and adults learning to swim, no matter what they themselves can do, have a sense of what the whole performance looks like. They see swimmers cruising back and forth all the time. Compare this with children in the third grade studying arithmetic, who typically have no clue about what math is really for, even in junior versions.

Second, practicing kicking and breathing as you hold onto a bar *is* a junior version. It's so junior that you are not even keeping yourself afloat, but you are doing everything you can at that point in a coordinated way, except for the grip that stops you from sinking. The same holds for many other early swimming exercises. From the beginning, there is an effort to put the pieces together, just so no one drowns.

If swimming is too far away from the usual business of education, consider early reading again. The same sort of complaint about swimming might apply to reading: How can we engage youngsters in reading in any holistic sense when they can't even decode? But the whole-language approach to reading in its less abrasively ideological forms has had a good answer to this for a long time. Yes, research demonstrates clearly that the decoding side of reading benefits from a phonetics approach. However, the endeavor of understanding narratives, arguments, explanations, and other such language forms involves much more than decoding and begins with oral exchanges. Indeed, research on reading development shows that the problems young readers experience reflect a mix of decoding difficulties, limited oral language facility and vocabulary, and a lack of background knowledge. Rich oral language exchanges can help with these issues. Seen in this way, whole-game undertakings like careful listening to and discussion about a story should be considered work on the larger enterprise of reading, even when all the actual reading students are doing at that moment focuses on decoding.

Junior version hard to come by? Get a little more imaginative. See the game in larger terms. Make the adjustments needed so "no one drowns," but with that in mind put as much of the whole game together from the beginning as you can. Besides that, be sure the learners, like the children learning to swim, get to *see* the whole game and participate around the edges, developing a sense of its shape and rhythm however much of it they are playing. We do well to live by a well-known statement from the seminal cognitive and developmental psychologist Jerome Bruner, who wrote in 1973, "We begin with the hypothesis that any subject can be taught effectively in some intellectually honest form to any child at any state of development."

Finally, let's say we have found our good junior version and got learners involved. Then what? How do we get to the full version of the whole game?

The journey to the full version of the whole game amounts to a staircase of junior versions with steps that become successively more complex and demanding. Early experiences of mathematical modeling can begin with simple whole-number arithmetic representing whole-number situations, move from there to fractions and decimals, and move from there to algebra and beyond. What expands is the repertoire of mathematical concepts and tools and the complexity of the modeling challenges. What persists is the idea of representing some piece of the world mathematically to reveal patterns and calculate consequences. Early experiences of literary interpretation can begin with simple stories and questions like, "What does this mean to you?" and "What do you see in the story that makes you say that?" It can advance to consideration of mythic elements in stories or character development driven by internal conflicts, and beyond. What expands is the repertoire of literary concepts and tools and the complexity of the texts. What persists is the idea of giving some evidence-based account of the work that illuminates its significance and its craft. Each step along such a staircase of junior versions is potentially another threshold experience, an entry into a more complex and sophisticated understanding.

And where does it all end? For any rich pursuit there is no real end. The possibilities for advancing a scholarly or practical craft further are endless. Today's most sophisticated versions are likely to be junior to tomorrow's. But we hardly need worry about the top of the staircase or whether there is one. The challenge of most of education lies much earlier along the staircase, getting learners started and moving them along with meaningful versions of the whole game.

The Quest for the Right Game

Recently I ran across two intriguing approaches to teaching ideas from biology: dancing mitosis and designing a fish. Two clearly dedicated and creative teachers shared these ideas briefly at a conference. If you remember your elementary biology, you may recall that mitosis is the process of asexual cell reproduction, by which the cell splits in two, each daughter cell sharing the full genetic complement of the parent cell. The rather complex multistep process of cell division in mitosis contrasts with the even more intricate process of meiosis involved in sexual reproduction, where there is an exchange of genetic materials between two parent cells.

Learners have difficulty getting the steps of mitosis straight. Dancing mitosis is one way to help them do so. In this teacher's approach, students in small groups took on the roles of various parts of the cell, designing a dance to play out the steps of mitosis, an active energetic way of recoding and representing to oneself this fundamental biological process. While there are canned versions of dancing mitosis where students simply learn predefined steps, my understanding of this teacher's practice was that the students needed to choreograph their own versions, a much more constructive endeavor.

Designing a fish also cast students in proactive roles. There the theme was adaptation to an ecology. Each student was asked to design a fish to fit within some aquatic ecology. The student had to devise distinctive and reasonable adaptations of the fish that gave it its own ecological niche, profile the lifestyle and adaptive advantages of the creature, and also position it taxonomically. I had a chance to thumb briefly through some of the reports students had written about their fish. The reports showed impressive detail and dedication to this exercise of the biological imagination.

Both dancing mitosis and designing a fish are whole games. They involve inquiry and require creating something that gives meaning to what otherwise might seem dry information. Both provide ways to approach something complex. Yet gradually I began to realize that in one way they were quite different from one another. Designing a fish looks toward its discipline of biology much more so than dancing mitosis does.

Designing a fish asks students to think *biologically* in creating their organisms, to consider issues of available food, competition, predators, and the like. Those same patterns of thinking figure over and over again in other contexts of biological inquiry. Designing a fish could be a threshold experience in biological thinking for these learners. In contrast, dancing mitosis asks students to think *choreographically* more than biologically. The steps of mitosis are right out of the textbook. The choreography helps students to learn how the steps work, good as far as it goes. But the knowledge really doesn't go any further than that. What can you do with it then? If generative knowledge is the goal, the students are probably having more of a threshold experience with choreography than with biology.

As I look across many examples where teachers have developed learning experiences with a whole-game character, I see the puzzle of dancing mitosis versus designing a fish coming up again and again. In general terms, *just because we have a whole game of some sort does not mean it foregrounds what we want.* Most of the interesting action may focus on something else.

The moral is simple: If one wants to advance students' understanding of and engagement with a discipline or some other area of learning, it's not just enough to have any old whole game in the neighborhood of the topic. One needs a well-targeted whole game, a whole game that engages learners centrally with generative knowledge and thinking in the discipline or area. Exciting activities are so seductive for teachers and students alike that it's easy to lose track of that goal.

All this said, I'm glad that students are dancing mitosis instead of simply memorizing the stages. And I'm glad they're learning something about dance in the process. I'm inclined to think that what they come to understand about dance is probably more worthwhile than what they come to understand about so very particular a topic as mitosis.

Keeping the Game in Motion

In the 1970s and '80s, quite a body of research developed around a dry-sounding concept with practical implications: *academic learning time.* Asking, "What's all the fuss about instructional time?" educator David Berliner offers a nice synthesis of the concept and results. The tale begins with the observation that there seems to be considerable slack in many settings of learning. Some of it comes from setup and transition time, some from passive listening, some from choice of activities that do not really focus on instructional targets, some from simple boredom and inattention.

To map how much students are involved in learning, investigators have constructed a number of measures such as allocated time, engaged time, and transition time. Particularly telling is academic learning time, roughly the amount of time students are involved in activities focused on the intended goals with a medium to high degree of success step by step. A relatively high success rate seems especially important for younger learners. Low success rates are always red flags. They demoralize students and, motivation aside, suggest that the tasks posed are too difficult for efficient learning.

Academic learning time predicts rather well how much students learn, much better than time sitting in class. Such research reveals the tricky logistics of settings of learning. Just because the learners are there does not mean that they are learning much. Effective learning requires artful management of the entire situation to lift academic learning time toward something close to the total time available, making the most of it rather than letting it slip away like sand between one's fingers.

The idea of learning by wholes does not automatically address academic learning time. It is all too possible for any of us to be engaged in a whole game without doing much at the moment. Again I think of baseball, an odd sport by this measure because most players are not doing much most of the time. Baseball is 10 percent action and 90 percent waiting—waiting for your turn at bat, waiting on base for someone to hit and move you along, waiting in the outfield for a hit to come your way, waiting on third base for a ball to come down the third-base line or a runner to approach from second.

There's not much hope for baseball. Waiting is intrinsic to the rhythm of the game. But baseball is an extreme case, and the general problem of keeping the game moving is fundamental to making the most of learning by wholes.

It may be helpful in considering academic learning time to think in terms of four attributes: pace, focus, stretch, and stick. For those who like acronyms, say *pfsst.*

Pace. Is each learner actively involved most of the time? Time that is adequately paced avoids drift and slack moments.

Focus. Do learners' activities fall within the core game we would like to see them getting better at, rather than taking some other form of busyness?

Stretch. Are learners being optimally challenged? When learners are finding everything easy, they are not likely to be learning much, nor are they when they are constantly encountering deep frustrations.

Stick. Are parts of the unfolding pattern of activity designed specifically to help knowledge, understanding, and skill stick in place? Stick includes elements such as deliberate rehearsal, reflection, stock taking, and revisiting ideas and practices later and then again later.

Put all these together, and we have what might be called the momentum of the game, the seamless energetic motion of the game in the designed direction.

Good *pace* can easily fall victim to set-up times and transition times. But beyond that, problems of pace often occur between the cracks, especially in classroom contexts. When students listen to a lecture or watch a video, are they just supposed to listen, or do they have a task to do that helps to keep them processing ideas actively? When a teacher fields a question from one student, what do the others take to be their roles, and how can those roles be made active? In group work, are the groups small enough to reduce the problem of marginal participants? In whole-class interactions with the teacher, is *wait time* employed, giving students time to think after a question is posed rather than calling on someone instantly, which on the one hand allows for little reflection and on the other favors students who already think they know the answer? When students ponder a question in class, are they asked to write down a few words, because when they have to write, that means mobilizing their thoughts to the point of specificity? Good pace, in other words, is a matter of organizing the subtleties in ways that promote the active engagement of most of the learners most of the time.

Even with a good pace, problems of *focus* arise when learners find themselves playing parts of the game that are too peripheral to generate much of the desired learning. Suppose, for instance, that students set up a mock store in the classroom. The idea is to learn things about handling money and basic economics. However, it turns out that much of the time goes into the incidentals of the store, furnishing and decorating, let's say. Or suppose that university students in a course on instructional design develop computer-based lessons as a project. However, it turns out that most of the time goes to struggling with the programming language rather than refining the way the learning works.

To generalize, any learning activity has secondary dimensions that require or invite attention. A certain amount of that can be enriching, but it sometimes happens that the secondary dimensions end up gobbling much of the learning time. Sometimes one hardly notices, because the secondary dimensions are engaging in themselves. Decorating the store may be more fun than running it! But what happened to the learning agenda? Good choices about the definition and structure of the activity can ensure that most of the time goes to the core.

Perhaps the trickiest problem of *stretch* is that different learners are likely to be in different places. What one learner finds altogether too hard for fruitful learning another may find altogether too easy. Sometimes this invites informal or formal diagnostic attention from a teacher. Even better, when you can, is to get learners to figure out their own appropriate levels of challenge. If the next two problems seem easy, skip ahead ten problems. What kinds of problems are you having the most difficulty with, and where can you find more of them and tips about how to handle them? All this looks forward to the entirety of Chapter 3, "Work on the Hard Parts," and beyond that to Chapter 7, "Learn the Game of Learning."

Finally, perhaps the trickiest problem of *stick* is the tendency in formal learning to leave things behind. Once we have finished the Industrial Revolution or linear equations or Deuteronomy, we do not expect to see the topic again for awhile. There is no systematic pattern of revisiting and revivifying. There is no systematic pattern of drawing things together into a larger-scale endeavor that integrates ideas and understandings from several directions. Learning by wholes is a help here, because that is the name of the game.

Gaming for Understanding

Imagine a snowball fight in space. A dozen astronauts hang above the Earth in free fall. They have arranged themselves roughly in a circle. In pouches on their space suits are supplies of snowballs, very expensive snowballs because the cost per gram of getting something into orbit is hideous. But this is just a fantasy, so we'll pay the bill with Monopoly dollars.

A signal sounds over their communicators. Each astronaut pulls a snowball out of the pouch and fires it at an astronaut on the other side of the circle. The question: Are they likely to hit one another, assuming that they are good shots on Earth? A larger question: What will happen as they attempt to continue their snowball fight?

Perhaps this puzzle brings back vague memories of the laws of Newton, studied in high school or college. So it should. You may want to ponder some answers for a moment before we go on.

A reply that might make Sir Isaac Newton happy would go something like this: As the astronauts begin the snowball fight, they also start to move way from one another. The gesture of throwing a snowball forward also pushes the astronaut backward, the principle of action and reaction. Not only that, but throwing the snowball also puts the astronaut into a spin, because the throw occurs away from the astronaut's center of gravity. Astronauts who want to avoid this would have to push the snowball forward from roughly their midsections, so the action occurs on a vector directly outward from their centers of gravity. Beginning to move away from one another and to spin, even as the gesture of the first shot unfolds, they are not very likely to hit anything, and the crew of the nearby space shuttle is going to have to invest some serious time retrieving drifting astronauts.

Here we have an example of playing a brief version of the Newtonian game of prediction and explanation. It is also a kind of test for understanding. If you understand Newton's laws of motion, you should be able to reason with them. If you do not, simply working from everyday intuition is unlikely to yield a sound forecast.

This also gives us an opportunity to examine one of the most fundamental goals of formal and informal learning: understanding. While rote and routine learning serve some ends well enough, almost everyone agrees that the larger aspirations of education require learning with understanding. Not so easily seen, however, are the answers to two questions: *What does it mean to understand something*? And *what's the connection between understanding and playing the whole game*?

So what does it mean to understand something? Staying with Newton for a moment, consider how one might know whether a particular student understands Newton's laws of motion. Many kinds of evidence should *not* convince us. The student may recite the laws. The student may write some correct equations. The student may succeed with three or four standard end-of-the-chapter problems. Despite all of that, this same student may urge that the astronauts in the snowball fight could easily hit one another if they weren't too far away and had good aim.

Our real criterion of understanding has to be performance. People understand something when they can *think and act flexibly with what they know* about it, not just rehearse information and execute routine skills. If you can't think with Newton's laws, you don't really understand them. If you can't think and act like a citizen, you don't really understand what citizenship is all about.

Earlier, I mentioned that some colleagues and I developed a framework for teaching for understanding. The heart of that framework is a performance view of understanding, the idea that understanding needs to be viewed as a flexible performance capability. To recall a couple of earlier examples, Lois Hetland in teaching about colonial

America was helping her students to become able to think historically. Joan Soble was helping her students to become more artful writers.

Sensible though this may sound, in many ways everyday language pushes in another direction. It's commonplace to speak of understanding as a matter of "having the idea," "getting it," or "seeing" what something is driving at. Everyday mention of understanding thrives on metaphors of possession, receiving, and perception. These ways of characterizing our subjective experiences of understanding are misleading. We can easily feel that we "get it" when we in fact do not. We can be sure we understand something only when we can think and act flexibly with what we know.

That brings us around to our second question: What's the connection between understanding and playing the whole game? The performance view of understanding provides a pointed answer here. Truly playing the whole game means thinking and acting flexibly in new situations, not just repeating old patterns in a stereotyped way. Playing the whole game is always a little bit creative. If every round of a game were the same, it would not be much of a game!

There is another way of thinking about understanding that is also helpful—mental models. When you pondered the problem of the snowball fight in space, almost certainly you were manipulating a mental model. You were picturing the astronauts floating in orbit, imagining what would happen as an astronaut threw a snowball. Likewise, in preparing for a job interview, you might imagine your way through likely scenarios. When sitting down to write a letter or an essay, you might make a quick mental outline. Research even shows that mental practice of athletic performances, such as shooting free throws in basketball, can improve the real-world skill.

Mental models are an important part of the story of understanding and the story of learning by wholes. Broadly speaking, mental models are images or ideas or structures we hold in mind. They need not be visual. They can use language, or our bodily kinesthetic sense, or our emotions, or other ways we have of representing things to ourselves. Whatever form they take, they support the flexible thinking and acting that is the mark of understanding. They give us mental representations for reasoning and exploration, just as an abacus or an artist's sketch gives us external representations for reasoning and exploration. Mental models are the game board of the mind.

Learning often means changing the game board, not just learning fancier strategies on the same board with the same pieces. Sometimes the game board we begin with incorporates mistakes and blind spots and prejudices. For example, think of the game board Newton had to start with. Everyday experience gives us a limited sense of the behavior of objects in motion, a sense embraced by Aristotle where objects spontaneously slow down and stop, their motion dissipating. The Newtonian conception reassigns slowing down to friction, a fundamental shift. Newton's view therefore represents somewhat different moves in a somewhat different game. Or look at the way someone like Gandhi tried to change the game. The inclusive equitable worldview of Mohandas Gandhi or Martin Luther King does not come so naturally to humankind. The usual beginning game board of group relationships has a clear "our side" defined by nationality, ethnic group, or religion, in stark opposition to "those others." A more inclusive conception that respects the other (without necessarily embracing the other) is hard but important learning, and another change in the game.

One thing that makes more sophisticated games hard to get is simply that one never gets to see them. There is not enough Newtonian motion or Gandhian philosophy around in everyday life to develop a feel for the game. One of the jobs of creative teaching and learning is to put the intended game within reach, to provide threshold experiences with it. A very important kind of mental model is a sense of the whole game. Recall the examples of learning to swim and learning to read. Children nowhere near staying on top of the water on their own already know the rough look of the entire performance of swimming, and children who do not know how to read but who have been read to a lot by their parents also know the rough look of the performance of reading. Such top-level mental models are powerful because they provide the big picture into which learners can fit particular elements, giving them meaning and purpose. It is not so hard to do this for swimming and reading. It is rather harder to do it for Gandhi, but surely we should be trying.

WONDERS OF LEARNING

PLAY THE WHOLE GAME

I wonder how I can organize learning around a "whole game." I probably need to engage learners in some kind of inquiry or performance involving problem solving, explanation, argument, evidence, strategy, skill, or craft. Learners would often produce something—a solution, an image, a story, an essay, a model. I should take care that the inquiry or performance not only engages learners but focuses on what I really want them to learn.

I wonder how I can tell whether I have a whole game. It's likely not routine but requires thinking; it's not just problem solving but involves problem finding; it's not just about right answers but involves explanation and justification; it's not emotionally flat but stimulates curiosity, discovery, creativity, camaraderie; it's not in a vacuum but engages methods, purposes, and forms of disciplinary or other practice in a social context.

I wonder how I can get learners started with a whole game even though they're just beginners. I could try to find a good junior version, maybe a very junior one. Junior versions at their best give learners threshold experiences, inducting them into a meaningful practice.

I wonder how I can keep the game in motion, keep the learners "playing." I might pay attention to "pfsst"—pace (learners individually involved most of the time), focus (learners thoughtfully doing what they're supposed to get better at), stretch (optimal challenge), and stick (review, reflection, rehearsal, and stock taking).

If I wonder about these things and do something about them, I'll be teaching for understanding. People understand something when they can *think and act flexibly with what they know* about it in new situations, not just rehearse information and execute routine skills.