Chapter 10
Recognizing the Value of Play

Jonathan J. Dickau

Play is the highest form of research.

Albert Einstein

Abstract For humanity to positively shape its own future, we must recognize the value of play as an essential activity for learning and creative expression. Cognitive Science researchers, Neuroscientists, and Educators, have told us this for a while, but lectures by top researchers in Physics stress that playful exploration is also crucial to progress in both experimental and theoretical Physics. Play allows us to learn and innovate. The value of play to research is greatly under-valued—compared to its benefits—by modern society. Given opportunities to playfully explore; anyone including students and scientific researchers will learn more, faster. Thus; encouraging play fuels innovation and progress—the engines of economic prosperity. Experts from all the fields above echo that observation, both in published works and in personal conversations or correspondence. To retain our sense of humanity and survive to shape the future, human beings must realize that play is every bit as essential as hard work is, to our growth as individuals and as a culture. For humans to positively shape our own future, we must exalt that which makes us human, and to do that we must recognize the value of play.

10.1 Introduction

What must human beings do, to shape the future in a positive way that helps us to assure our survival and avoid a dystopian fate? Can Science aid our cause, to help us create a futuristic utopian ideal instead? Can the progression of knowledge

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and the growth of human knowledge about the universe and ourselves provide the means to uplift and unite the human race through understanding—as in the Star Trek vision of Sci-Fi pioneer Gene Roddenberry? The possibility for such a future remains open, but there is a danger we will undermine our capacity to engineer this outcome, unless certain trends are reversed. Science can help us create a positive future for humanity, but we must be willing to apply what we have learned more broadly, and to exalt the search for knowledge and the process of learning over the information learned and the specific insights gained. To do this; we must recognize the value of play. Researchers like Alison Gopnik [1] have observed in the playful activity of the youngest children, the emergence of sophisticated experimental protocols to isolate variables and reveal how things work—while they play with various arrangements of objects—which prompted her to call them "little scientists." We need to cultivate this scientific curiosity, and the playful mindset that supports it, not only for the young but for older folks too—especially in the innovative workplace and in academia. If we want adult researchers and developers to make great advances and discoveries, we must give them freedom to play. But before that; to properly educate our young people for careers in Science, Technology, Engineering, or Math, we must encourage them to playfully explore ideas and concepts—and not to merely memorize facts—because *this* is what helps them develop the mental acuity and problem solving ability which will allow them to succeed and excel.

Humanity can make great strides, and *could* create an idyllic future using what we now know. However; we *must* encourage a playful approach toward acquiring knowledge, and an appreciation of learning and knowledge for their own sake, to do so. While learning specific bits of information makes an individual fit for a range of tasks, it is more general knowledge that allows a person to move from one task to another as required by real-life circumstances. Humans routinely exceed the capabilities of machines in this area, but are expected more and more to function like automatons rather than humans. This expectation is now projected onto Education, and disturbingly placed on both teachers and students. To prosper as a race, however; we must exploit what makes us uniquely human and gives us the power to innovate. The innate intelligence of play is a wonderful path to understanding, giving humans the capacity to become scientists. At its core, Science *is* play! Scientific exploration is a ritualized extension of the playful exploration and experimentation of the very young. To a scientist; what we don't know about the universe inspires no fear, but offers a sense of awe and wonder like that of a child. Unfortunately; we have not learned how to nurture the behaviors that lead young people to become thinkers and innovators, because our culture encourages only those who are very good at Science to have the fun of working in that field. We need to communicate that is isn't all hard work or memorization, that Science is and should be fun, and that there is great value to a playful approach in subjects like Physics or Math—or in other areas of Research and Development.

At the frontiers; Science is less about facts—and more about how we learn what is real. In lecture after lecture; I have heard top experts in Physics—including Nobel laureates—expound on the need for an open-ended and playful dynamic, to assure research success or scientific advances. The expectation for a predictable outcome can kill progress in research, because the swiftest progress is often made when there is only an interest to see what nature is telling us, with no specific expectation of what we will find. Though everyone looks for predictable results and a good return on their investment, progress in research defies such expectations, and is stifled by them. Anton Zeilinger lectured at FFP11 in Paris that he once told his employers “If you want results, don’t expect results,” and spoke to the need to be playful about how we approach research. At the same conference, CERN theorist John Ellis told a story of a visit once from Margaret Thatcher where he was asked about his job, and he professed to working through pages of difficult calculations to predict what they would find, then hoping to see something else when the experiment was run. Of course; Mrs. Thatcher asked him “Wouldn’t it be better to actually see what you predicted?” And Ellis replied “No, because that way we wouldn’t learn anything interesting.” And so it goes, because the rest of the world sees knowledge as a collection of facts and scientists see it differently. To them; knowledge is more like an endless progression of new discoveries and better understandings. The scientists among us see the scientific method and scientific knowledge as a way of learning about the world, and they retain a sense of openness and wonder that the rest of us have lost, but is greatly needed for progress.

When I say we need to recognize the value of play; I mean it is something we *must* do, to prepare today’s young people for careers in STEM subjects, and the rest of society for working with the advanced technologies of tomorrow. But beyond this, we should understand that a playful atmosphere in research and development labs is a legitimate and responsible tool for progress. While prediction and control of outcomes is essential to other endeavors, trying to impose this mindset on scientific research will do more harm than good, because Science is not like Manufacturing or Construction—where the stages in a project’s progress can be charted and timetables adjusted through the allotment of resources. In those endeavors; the unknown is the enemy, which creates uncontrollable uncertainties and prevents prediction of outcomes or adherence to timetables. Science treats the unknown in a fundamentally different way, because the things we don’t know—that make reality scary for the rest of society—are exactly what makes the universe interesting, exciting, and fun, for scientists. The unknown is ultimately what drives scientists to pursue knowledge. They gain an advantage by studying what other people have learned, to benefit from other’s past victories. However, scientists do not imagine knowledge to be a mere collection of facts that are concrete, lifeless, and unchanging, but instead they see knowledge as a living body of understanding—that helps us to shine a light on the nature of reality, and allows us to unlock its secrets. More importantly; those who enjoy the most success in Science are those who remain playful in the face of the unknown.

We find, especially in the sciences, that adaptive reasoning skills are more essential than information or knowledge in a fixed form. And yet; we seem hung up on teaching facts, or presenting information as facts, rather than realizing that the progression of knowledge demands a different approach. While many use the explosion of knowledge and the speed technical knowledge becomes obsolete as a rationale to teach students more and more facts in the short time available to educators; experts assert that students would be better served if more time was spent on teaching how to learn and less on memorizing facts. Unfortunately; what the experts know has not reached those who set the standards and oversee their implementation—leaving parents, students, and educators, scrambling to make up for what planners and administrators have not learned how to do effectively. It is true that students of today must learn more, and must learn faster, to graduate with the essential skills to function in modern society. But their success hinges on learning how to learn, and how to think for themselves. Nor can we imagine that the older generation is expendable, because they must convey a love of learning to the young—for young people to become inspired by the pursuit of knowledge for its own sake. One way we can create a better future is to encourage playful engagement with Science and Math, where we make it fun for all. If we can nurture the playful spirit all humans have as infants, and scientists need to advance human knowledge; this is how humanity can shape the future most positively.

10.2 Playful Learning Landmarks

Any learning process must proceed through stages, where basic knowledge acquired early on is then applied later in more complex settings. An important landmark in early childhood development is called object constancy. This is when we recognize that things are persistent, so they continue to have an existence even when they are out of sight or reach. For a very young child, a game of 'peek a boo' yields great pleasure, because it is a mystery every time the adult hides and a new discovery each time they emerge, but later on there is no mystery—since the constancy of objects and people is assumed. Once that bridge is crossed, though, a large number of other learning landmarks await as we discover how different collections of objects and people can be combined, or can interact. This is where play begins, and how our process of learning commences. Children play to figure out how things work, and to see how they are meant to go together or what is their function, and this is very much like the experimentation of scientists. Children are curious and they want to explore—to see different things, try different things, and go different places—learning how things change, and what stays the same. One important skill we must learn early on is how to navigate, therefore, and this leads to another learning landmark. Navigation at sea was made possible by a process called triangulation, and this same process is what allows toddlers to figure out how to get around—once they are mobile. As one moves, objects along the periphery grow as one gets closer and shrink as one moves away, so this allows us to make a determination of both our relative position and the sizes of objects.

One can make increasingly more accurate determinations, by learning the size of various landmarks and their distance from one another. But it all starts with a process of 'observe, explore, and compare'—repeated endlessly—where one comes to learn 'this is bigger than that' and 'this span is farther than that one.' Whether the landmark is a tower on shore for a ship at sea, or a refrigerator in the kitchen for a toddler taking his or her first steps, the process of triangulation is the same. Generalizing a bit, we see a process of dimensional estimation, or determination of the dimensionality of objects and our surroundings. This is something we must all learn, early on. Once this insight is acquired, however, something remarkable occurs. The research of Judy DeLoache [2] shows that children below age $2\frac{1}{2}$ display a 'dimensional confusion,' where they will attempt to put on shoes much too large or get into a toy car or chair that is much too small to sit in. They also have difficulty distinguishing 3-d objects from 2-d representations at that age. But once the developmental landmark is reached, that allows children to accurately estimate the dimensions of things around them, they also acquire an increasing ability to recognize and employ symbols, and to develop symbolic reasoning. My deduction, as noted in previous work [3], is that this ability to triangulate and to estimate sizes and distances is specifically what enables us to decode the symbolic realm, and to develop symbolic thinking.

What starts out with a literal cycle of observation, exploration, and comparison, becomes a process of systematic experimentation—where comparisons become more subtle as 'observe' and 'explore' take on much broader definitions. At first; a distance estimation may refer to the physical distance between two points in a room or a yard. But later; one can estimate the distance between abstract concepts in a multi-dimensional symbolic space, which represents the extended variables in the domain where those concepts have a specific range. Thus; Mathematics can be applied to ideas and relations between them—in the domain of pure thought—and one can use the same type of reasoning to understand the fundamental nature of physical reality through Physics. So when children playfully explore, and end up learning how to navigate by estimating and later grasping dimensionality (thus knowing 2-d from 3-d), they can learn about the language of symbols. This, of course, unlocks the door to all kinds of learning that was not possible before. In my view, this conceptualization is exactly like the brainstorm of Gerard 't Hooft, the Holographic Principle [4] relating 2-d and 3-d realities, which unlocked for physicists endless realms of undiscovered information, and opened new roads to further exploration and discovery. If this insight is put into perspective; it is perhaps like the advent of language, in terms of the transformational effect on our culture. It may take a while, considering how slowly the understanding from Relativity and Quantum Mechanics has filtered through into the general population. But maybe to future scientists; those two pillars of our present-day scientific knowledge will be relics from a period when Modern Physics was still in its infancy, before the 'Holographic Universe' Era.

10.3 Child-Like, Adolescent, and Adult Play

Play is the road to learning, but not all playing is the same. As Gopnik and her colleagues have learned [5], the play of very young children tends to be a mission of learning and discovery which is very much like the research of scientists. Pre-literate children spend a lot of time learning about the nature of reality—discovering how things work by testing their theories. But later development brings more interactive forms of play, because the capacity for interaction increases as we move further along nature's neurological and physiological timetable. As physical development brings more complex and sophisticated neurological structures online, the ability becomes available for more complex and sophisticated forms of social play. The recent work of Joseph Chilton Pearce and Michael Mendizza [6] emphasizes the value of play for learning at all ages, and traces how the forms taken by playful activity evolve over time, and with the development of our cognitive faculties. How we learn, at each stage of development, is hard-wired by specific patterning of natural development—but while this generally happens at a specific age or a distinct range of ages, it is uniquely dictated by the neurological development of each individual, on a case by case basis. This suggests that we need to tailor our instruction to what children are primed to learn at each stage of their neurological growth, rather than imposing an external timetable on them.

My own talk at FFP11 in Paris [7] detailed how understanding the structure of the brain and the changing nature of play for different age groups aids both success with Science and Math instruction and research progress. While the play of young children tends to be amicable, at least with some adult supervision, the play of adolescents takes on a different character—especially for males—becoming more competitive as the teen years progress. And while modern society celebrates competitiveness; this adolescent form of play is *not* the final stage in our development, and competition is *not* what fuels our greatest and highest accomplishments. The growth spurt in the brain initiated at puberty brings the deepest portions of the brain to their final stage of development, while beforehand and afterward the emphasis is on developing the structures that support higher cognition and abstract reasoning. Therefore; while child's play and mature or adult play emphasize higher-brain function, which is expressed in development of the neocortex, adolescent play is more involved with the activity of lower-brain centers. After its final growth spurt; the action of the midbrain or hindbrain is automatic, however, and there is no capacity for any additional learning, reprogramming, or higher cognition. The character of its reasoning is primitive or primal, and it has been called the 'lizard brain' because that is how it thinks. While over time our 'lizard brain' can be retrained, it appears to be fixed shortly after puberty because it responds to change so very slowly. This is why it is important to move beyond adolescent play, and to emphasize activities that involve or activate the higher centers of the brain.

While it is not obvious; play is the most cerebral activity of all, in all its forms except adolescent competition, because an attitude of playful exploration stimulates activity and learning in the neocortex—the very highest region of the brain—which supports the most sophisticated types of reasoning. If we wish to reap the fruits of cerebral activities, we need to curtail activities that force us to use the 'lizard brain,' and emphasize those that allow us to use the neocortex instead. When people are intimidated into compliance, or compelled to adhere to an artificial timetable, their ability to make progress suffers. While necessity *can* foster innovation, often the best scientists can do is create the ideal conditions for a discovery to be made, and then wait for nature to reveal herself in the experimental results. Even in the face of extreme need, it is better to remain playful—tossing ideas around in one's head—than to become focused on how important it is to get the job done. That is; the ‘lizard brain’ cannot help us to innovate any faster, and struggling to work harder will not reveal the answers quicker either, because it activates a portion of the brain that is not up to the task. Instead of working harder; we need our researchers to be more playful, and should reward them for doing things in a way that allows use of the highest centers in the brain and facilitates higher reasoning. So; we must coax people away from competitive adolescent play to more cooperative adult play, and a ‘win-win’ mentality, to keep things cerebral.

10.4 Teaching Lifelong Learning

The notion that knowledge has value for its own sake is unpopular these days, as applying one’s education toward finding employment in your chosen field is the paramount concern. Everyone is looking for a good return on their investment, and the entire field of Education—from pre-school through graduate school—is compelled to create measurable value in terms of employability. But I question whether this industrial vision of education serves the needs of our young people, or delivers the knowledge they need and the skills they require to use it. Teaching only information, delivered in pre-digested allotments, robs students of opportunities to learn that growing brains and nervous systems require. Compelling teachers to teach what is on the test first, and only later to convey ideas and concepts, frustrates the natural process by which learning occurs—because things ‘want’ to happen in the reverse order. In a local lecture; Education author Alfie Kohn told how one class learned to measure on its own, through a process of guided discovery by which they developed their own units of measure—introducing units and measures in a way those students will never forget. What kids learn through playful exploration is retained indefinitely. But we must assure that this fact known by Education researchers and innovative educators is shared broadly enough to be helpful. Speaking with Kohn after his lecture; I informed him that the same rules of learning he emphasizes for students and educators also work for researchers at the frontiers of Science, and he had not heard this before, though it came as no surprise. But we need to make sure such knowledge is more broadly available, or more widely known.

While I appreciate the need to educate our young people, and the fact that they are our hope for the future; I feel that lifelong learning is too often neglected or left to chance, while we focus on the young. If we view educating our adult population as less essential than educating kids, we are robbing both our children and our adults of the learning experiences they need to usher in a better future. Without a well-educated adult population, our children will not have the learning opportunities to create the kind of world we desire—regardless of the quality of the education they receive while at school. When the adults at home are sharper and more knowledgeable, this encourages young people to learn more, while uninformed adults tend to make learning difficult for kids. Unless parents appreciate the need for education, and can assist in their children’s learning process when not at school, the prospects for a bright future diminish—because essential skills are never imparted. We are quick to assume the skill set of many adults has become outdated, in modern times, because it is believed that all knowledge has a half-life—a limited range of applicability—before whatever is learned becomes obsolete and therefore inconsequential. This is only a half-truth however, as some knowledge is enduring or universal, and there is evidence the survival of an older generation and the wisdom of elders in our culture allowed humanity to escape doom on several occasions already [8], from the pre-historic past until today.

My recently departed friend Pete Seeger was a playful-minded fellow who remained sharp and continued actively learning, well into his 90s. If you asserted that he had no useful knowledge to impart at an advanced age, because everything he learned in school was obsolete, quite a few people would tell you otherwise. He and his wife Toshi, who passed last year, were passionate advocates of lifelong learning, supporting Science and Math education for girls as well as boys, for young and old people alike. But I've also been privileged to interact with Professors Emeritus, and other elders of academia who still have active minds—with a lot to teach and a passion to make their point—at an advanced age. Frank Lambert, now 95, led an effort after retiring from teaching, to reform the treatment of Thermodynamic Entropy in Chemistry [9]—moving it away from the notion that entropy is disorder, and toward a metaphor of energy dispersal or spreading—where now around 90 % of Chemistry textbooks have dropped the disorder metaphor. Steven Kenneth Kauffmann, who is 'only' 75, continually amazes me with a steady stream of new ideas that upgrade my understanding of Physics and challenge my intellect, in papers [10] and correspondence full of keen insights. So when I see colleagues in their 50s (my own age) or 60s marginalized, because too much of their knowledge is outdated, I have to wonder if those who determine this have any understanding at all. When I had questions about Decoherence and H. Dieter Zeh took time to correspond with me it was priceless, for example, because I got my answers directly from the world's foremost expert, and his advanced age was no issue.

10.5 Concluding Remarks

Talking about play; most people think of it as a way to waste time or enjoy some time off—when they are not working. Few get paid to play, in our society, and many of those who do are either involved in a competitive sport, or are musical performers, actors, and other entertainers. But if Science is to help us to create an idyllic future as in the Star Trek universe; we must appreciate the role that play takes for scientists, mathematicians, inventors, and other innovators. Sure, there is serious work involved, and one must get every detail exactly right—before one can establish the working conditions where the playful phase of the exploration process provides dividends. However; playful researchers make more discoveries, and win a larger portion of the accolades in Science, than their more timid and conventional peers. Speaking at FFP10 in Perth; Nobel laureate Doug Osheroff explained that researchers must be willing to question the wisdom of today's theorists, and to look in unexplored regions of the parameter space, in order to discover new things. His talk on "How Advances in Science are Made," which he has delivered in several venues [11], was full of examples of how scientists must retain a sense of play in order to make progress. It seems clear that, in the realm of scientific research, the spoils go to the playful rather than the methodical.

In today's world, where a guaranteed return is a requirement for investment of resources and everyone is scrambling for a piece of a shrinking pie, the need to provide an open-ended environment to researchers—to foster progress—is often forgotten. Furthermore; now when researchers need more opportunities to play and explore—to accelerate progress—we force them to deal with tighter and tighter restrictions, and this slows the pace of progress instead. Efforts to have scientists conform to the norms of prediction and control—favored by administrators—are doomed to backfire, because these misguided efforts fail to grasp the fundamental nature of research, and the standard methods are designed for tasks that are very different. Yet increasingly; researchers face a situation where, upon entering the workforce, they are burdened with heavy workloads and administrative duties—that take them away from their research, and slow their progress [12]. When we send our most able scholars the message that it is not OK to play and they must do 'serious work' instead, we are doing them and our world a disservice. They are the ones who will create the idyllic future that Roddenberry envisioned, if we are to see one at all. We should be celebrating scholarly achievements to as great a degree as we do those of athletes on the field! Perhaps more importantly; we should revere new knowledge once it is received, because seeing great scholarly accomplishments like Perelman's proof of the Poincaré conjecture [13] shows us the inherent worth of such pursuits. Of course; a full appreciation of the importance of that work would require a much more well-educated general population.

The challenge, then, is to inspire more people to seek higher education, to make Math and Science more fun to learn, and thus to elevate the general intelligence of the populace, in the core STEM subjects. To do this; we must acknowledge that these are playful pursuits by nature, and make it OK for scholars in these fields to actively play. Play is far more universal, being the root source of *all* learning, and indeed of all consciousness and cognitive intelligence, but it clearly finds expression in these subjects. While Math and Science are full of hard topics to learn; they are, at their heart, fun! But this is only one reason I say that Science is play. The very best scientists, those at the forefront of their field, seem to have a defining characteristic in common; they retain a sense of play, delighting in the awe and wonder of the natural order. And this is something all young humans display at an early age. For us to be the creators of a better world; we need to nurture and cultivate the playful spark of curiosity we are all born with, which is a defining characteristic of all human beings. Knowledge is worth having for its own sake, apart from any financial benefit it might confer. However; the kind of knowledge scientists seek is not a collection of facts, but a living, breathing thing. Science brings us a kind of knowing that is dynamic and endlessly expands the boundaries of knowledge. It is not a commodity that can be contained and retained, but rather it is a playful never-ending voyage into ever-increasing understanding and intelligence. This is what we need most, to create the idyllic future we want—just as Roddenberry envisioned. Play is the most fundamental freedom for children, and it must be preserved, but giving Science-minded adults freedom to play will help humanity reach the stars.

10.6 Reflections and Observations

Having the opportunity to comment further here, after learning a panel of experts chose this essay for a prize, brings a kind of validation that my message was heard. However; I know impressing scientists with the idea that a playful attitude has value for learning and research is like ‘preaching to the choir.’ The tough thing is selling the idea to business people, economists, and financial gurus, that letting scientists and developers play more freely is the surest road to increased innovation and progress. But it is the honest truth! Playful exploring allows us to discover and develop things that no amount of memorized information can yield. You can see a gleam in the eye of the most successful researchers that shows they have not forgotten how to play or why remaining playful about coaxing nature to reveal her secrets can yield swifter results. Young people need to learn that doing Science can be a lot of fun, and that folks who explore the frontiers of knowledge lead interesting and exciting lives. Having heard him speak; I imagine Quantum Physics researcher Anton Zeilinger goes to work in the morning thinking “this might be the day I learn something nobody else has seen before.” That kind of job incentive is a powerful motivator for progress, and it is something palpable for all the top researchers—a fact that seemingly eludes those who see progress solely as the incremental product of their hard work. Progress needs thinkers and innovators, and those people need the freedom to look beyond predictable outcomes or safe assumptions—to playfully explore where no one has gone before—in order to create a brighter future.

People working in Science, and innovators working to create the technologies of tomorrow, *must* see things differently—or need to understand there is more to the story. While some things decidedly *are* the incremental product of work done over time, research and development are fundamentally different. The hard work comes mainly during the phase of preparation, where all the tools and resources necessary are assembled and utilized—to create the pre-conditions for the real action to begin. Then comes the stage of the process where hard work is no longer enough, and one needs to have the ability to play well—to go beyond that point. It matters little what the area of specialization might be, within subjects like Physics, Chemistry, and Biology; the same rules apply. Experimentalists play with equipment and parameters, or samples of various kinds, while theoreticians play with ideas, but the playful nature of their activity is very much the same. Different possibilities must be examined, from every possible angle, to ascertain what is, might be, or definitely is not true. And only when a number of different models or interpretations are sorted into such categories is there an increase in our knowledge and understanding over time. To ‘toss ideas around’ in one’s head is an essential skill for any scientific researcher or technological developer, but this is fundamentally different from the kind of thinking that is directed toward a specific goal, or uses a single standard method to solve a well-understood problem—because many different things must be tried, and you don't know exactly what will work best.

Play is essential to many kinds of endeavor, and to achieving the highest levels of performance within that field. It is not the absence of work, as some would have us believe, but instead; play is often very hard work, yet it is joyfully undertaken, in the spirit of exploration. This is what fuels humanity's dreams of progress, and leads us into the stars. The wide-eyed sense of wonder and awe, which is common for children, is unfortunately uncommon for adults. However; many adults I've met who retain this quality are scientists and developers, people who explore the frontiers and use their brains in their daily work. And I can state unequivocally, that those who most exude this childlike sense of wonder are the people at the very top of their respective fields, who have made significant discoveries or important contributions to Science and Technology. So it is obvious that being playful works, to foster innovation, speed the process of discovery, and boost progress. Our institutions and society need to respect and endorse the efficacy of play, in all creative endeavors, rather than perpetuating the myth that play is not work, or pretending it is not essential to the highest levels of performance. As a culture; we need to become much more like little children—by allowing and encouraging adults to be playful in their pursuit of knowledge—if we are to gain the skills that will enable us to ascend to the stars.

If we want to see a future that resembles the one in Gene Roddenberry's 'Star Trek,' we need to foster a culture of lifelong learning, by sending a message to both young and old that the pursuit of knowledge is a worthwhile goal. Solving the problems that face modern humans requires a commitment to using our intelligence to conquer them, but if we rise to that challenge; the entire universe is ours to explore! Only the unending increase of knowledge will bring us to the fruition of that dream, but it might also lead us to a future even brighter than Roddenberry could have imagined. The thing is; we need to begin moving in that direction soon, if humanity is to get there at all. By encouraging the playful exploration of possibilities and the playful pursuit of knowledge—which values what we don't know as much as what we know—we allow the discoveries to come sooner, and foster a greater understanding overall. The truth is; there is far too much shallow reasoning in today's world, and this is part of why we face some of our most vexing problems. Ergo; if we want to turn that around, we need to foster and inspire deep understanding—which contains or embodies the power to solve problems. Only a truly deep understanding can solve the most difficult problems we face, and a playful approach to learning can make that understanding possible. The idea that play is expendable comes from the mistaken notion that knowledge is a collection of facts which can be memorized, but memorization does not confer the same problem solving ability as playful learning. This is why I assert that we must recognize the value of play, in order to create the bright future we desire.

Endnotes

Dimensional Estimation Through Triangulation

Triangulation—the ability to triangulate, to navigate or to determine the size and distance of objects, depends on perspective—as generalized in Projective Geometry—but the basics are encapsulated in Trigonometry, the study of triangles. Using ‘observe, explore, compare’ one could note that a lighthouse tower on shore at sea is as big as one’s fingernail at arm’s length—when it is first sighted—and as large as the entire finger at arm’s length—once one moves closer (as in Figs. 10.1 and 10.2). Using the properties of right triangles; we can calculate how much closer we are, or even exactly how far away—if the angles of elevation have been measured precisely and it is a landmark of known size. But this essential skill for navigators is acquired at an early age by every child, in the process of their learning how to gauge the dimensionality of objects and the environment.

The most basic relation in Trigonometry is called the Pythagorean Theorem, which states that $c^2 = a^2 + b^2$, where c is the hypotenuse, and a and b are the legs of a right triangle (Fig. 10.3). This formula allows us to calculate the length of any side, knowing the other two, and given that the angle between a and b is a right angle. It is almost as simple to find the unknown distance, given one side and an angle. If we know the height of the tower (which stands at a right angle) and measure the angle of elevation Θ, we can calculate our distance from the tower using the formula $\tan\Theta = \frac{height}{distance}$. This allows our estimates to be made precise.

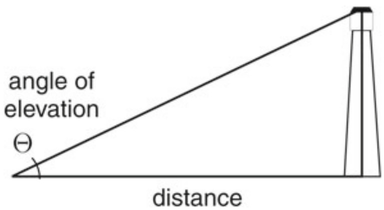

Fig. 10.1 A lighthouse tower appears smaller at a distance

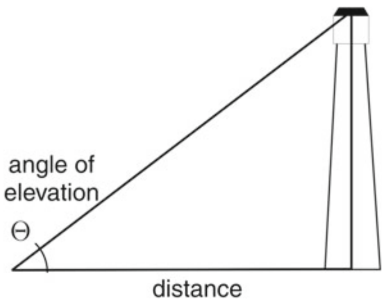

Fig. 10.2 The same tower appears larger when closer

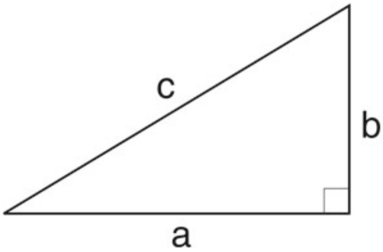

Fig. 10.3 The Pythagorean theorem gives any side of a right triangle, if we know the other two

Ranging—the process of dimensional estimation requires calibration, in order to be effective. We must learn how big things are. Very young children display 'dimensional confusion' when experimenting with the calibration of their grids, to determine what is 'close enough' to work and what fails to match their needs or expectations. Children above the age of $2\frac{1}{2}$ lose this 'confusion' and display increasingly more ability to distinguish the dimensions of objects and their background environment correctly. In addition to estimating size and distance, children learn to tell the difference between 2-d surfaces or images and 3-dimensional objects, as well. This is one of the key factors that sets the stage for the acquisition of knowledge using symbols, and for symbolic reasoning, in human children.

Playful Comments

Michael Mendizza commented (after reading an earlier draft):

> You are circling around the tip of a galactic iceberg.
>
> Consciousness is play. Thought is play. To treat thought and consciousness any other way is to 'play falsely,' pretend that thought-consciousness is not what it is, which is a form of self-deception and shared delusion.

And he continued with these words:

> Personally I question pinning so much of your thesis on science. Humanity, sanity, appropriate and sane social orders, kindness, the ability to see 'what is,' which is the essence of science and also what contemplative traditions call enlightenment, is much more fundamental. All of this critically depends on appreciating that play, Maya, is what thought and consciousness is. To not see this is to live in delusion, which we do. Play liberates us from 'playing falsely' with thought and consciousness.
>
> Play is also the gymnasium of imagination, the place where we develop our capacity to create, which mirrors and is creation itself. The enlightened use of imagination is causal, literally we are the image and likeness of creation (God if you must), but playing falsely with thought consciousness means that what we create is distorted, and therefore we become the enemy. We are the enemy because we don't understand the true nature of what consciousness-thought really is. Play!—Michael Mendizza (on 1/31/14)

Playful Learning Resources

There is such a wealth of information about play available, that my repeated attempts to collate the relevant sources have only increased the number I found. I should start by recommending the books and articles of several authors I cited, especially Alison Gopnik, Joseph Chilton Pearce, and Michael Mendizza. Of course; books by Richard Feynman like "Surely you're joking.." and "What do you care what other people think?" contain plenty of insights on how a playful attitude benefits learning in Physics, but Michael Mendizza heartily recommends the works of David Bohm, as well, for deeper insights into how play is integral to learning and thinking. He also introduced me to the work of Dr. Stuart Brown, whose book "Play: How it Shapes the Brain, Opens the Imagination, and Invigorates the Soul" reinforces all of the messages in this essay, and provides additional insights on how play is essential to a broad variety of activities. The following links may also be helpful.

http://www.nifplay.org The National Institute for Play—founded by Stuart Brown M.D.

http://www.ted.com/talks/stuart_brown_says_play_is_more_than_fun_it_s_vital A TED talk by Dr. Brown "Play is more than just fun"

http://ttfuture.org Touch the Future—a project of Michael Mendizza with a team of experts

http://www.nurturing.us The Nurturing Project—another effort of Michael Mendizza

http://www.journalofplay.org The American Journal of Play—a multi-disciplinary journal devoted to the study of play. It has an impressive collection of papers stressing the importance of play to learning, as well as documenting its role in establishing a healthy society.

And finally; I am assembling my own collection of work on this subject, which will feature additional links to content found on the web, emphasizing the importance of play to Science.

http://www.scienceisplay.org Science is Play—a project of Jonathan J. Dickau

In closing; as my departed friend Ray Munroe would say,

Have Fun!

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