The Curiosity Cycle: Preparing Your Child for the Ongoing Technological Explosion

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Preface

Curiosity leads to flexible and adaptive thinking. The world is changing fast: Rote memorization and brittle thought are not going to be sufficient, and being flexible and adaptive will be increasingly important as individuals have more power to determine their destiny. Being curious is also a fun way to live because there are always more questions to be answered. Creating curiosity is about creating anticipation. Novelists know this, and they foreshadow events by giving hints of what is to come. Sports producers also know that curiosity is important. During the hype before the big game, they talk about the history of the teams and players, and they talk about how the players on the opposing teams match up to each other. As a parent, you have the power to create anticipation for topics that your children will eventually learn in school and use on the job and in their lives.

Curiosity is central, but children live in physical bodies and in a world increasingly inhabited by smart machines. We are social creatures, so our children need to understand how others think. We are also emotional beings, and our children need to understand how their own minds work and sometimes deceive them. Additionally, our little social and emotional creatures need to be adept at interacting with computers, which have alien thought patterns that are neither emotional nor social. Computers are becoming increasingly skilled at performing simple computations on the squishy events and objects of real life. They can perform these calculations with dizzying speed, but they still need human creativity and curiosity to direct them. This book will help you to prepare your child for this environment.

Kids are under pressure to excel in school, and unfortunately they spend too much time in the classroom learning how to do well on tests. The principles presented here will help your child achieve an intelligence that is broader than test scores. The goal is not to push kids harder, but to create a curiosity within them so that they are intrinsically and internally motivated to go out and acquire information. This is why the title of this book references curiosity instead of success or intelligence. The idea is to give children internally driven curiosity and then to let everything else follow naturally.

Is it even possible to teach a kid to be curious? A recent book titled *Freakonomics* pointed out that activities such as taking kids to museums and reading to them is not enough to improve academic progress. The authors say that raising intellectually successful children is based on who you are, not what you do. I agree that taking kids to museums is not enough; I propose that it is *how* you take them to museums that matters. Vince Lombardi said: “Practice doesn’t make perfect. Perfect practice makes perfect.” It is not just about exposing your child to culture, it is *how* you expose your child to new ideas and *how* you interact with your child. The Curiosity Cycle points the direction toward that “how.”

You’ll find the approach I offer is different from most books about raising intellectual children. The principles presented here were developed while I was researching the question of how to build smart robots. I worked toward enabling robots to learn about the world in the same way that human children do. This research took me deep into the current literature on developmental psychology with the goal of developing a set of *actionable* principles that could be articulated and implemented on a robot.

This book is primarily targeted at parents of young children (from birth until about 10 years old), but my hope is that anyone interested in either human or artificial cognition will enjoy reading about the principles covered here. Where there was a trade-off to be made between scientific rigor and understandability, this book always errs on the side of understandability. But, for the interested reader, there are notes and references in the back.

I love thinking about where we have come from and watching the world change toward our unknown future. Since both the past and the future belong to our children, I have tried to weave those aspects into the narrative of how they can be curious and excited about the world around them. Enjoy!

Chapter 1

Constructing Intelligence

1.1 Children Construct Their World

Most of the world is hidden from view. Our environment is too big and interconnected for our perceptual system to show us everything. We feel like we see it all, but that is just an illusion. Consider the experience of learning the meaning of a new word. Once you learn that word, suddenly you see it everywhere. This is partially because words follow fashion like everything else, but the word probably didn't just pop into existence. It was there, and you were just ignoring it without realizing it. The word was just background noise. Similarly, have you ever suddenly seen a new building on a familiar drive home? That building had always been there, but for some reason you never saw it before. The world is massive and continuous, but because our finite brains can't possibly process all of it, we carve out what we need and ignore the rest.

We carve our experience out of the continuous world based on what we know. Our eyes don't work like video cameras. Instead, they dart around from place to place, and using the bits and pieces we see combined with our background knowledge, our brain constructs an impression of the events around us. Once, I thought I saw a cat while walking in a parking lot at dusk. I didn't wonder if I saw a cat. I saw a cat. But as I got closer, I recognized that it was in fact a beer bottle. If I had never had any experience with cats, I wouldn't have initially thought that I saw a cat, and my brain would have interpreted the beer bottle as something else. My brain constructed the image of the cat because it estimated that a cat was a likely thing to find at that location.

Because what we know determines what we see, learning new things changes how we experience the world. Consider trees: Before you learn about different types of trees, you just look at the landscape and see generic trees. You might see some are big and some are small, and some have pointy needles and some have broad leaves, but for the most part they are just trees. Learning how to identify some trees changes what you see. You no longer look at the landscape and see trees; instead, you see live oak trees, southern magnolia trees, and cedar elms.

Children are just like us except they have less knowledge. Children also explore the world more broadly than adults do, and their attention is less focused. From their perceptions of the world, children construct knowledge. Children are naturally curious and actively build causal explanations of events, and this chapter discusses how to help your child make the most of this natural and amazing ability.

1.2 The Curiosity Cycle: Actively Constructing the World

How can you help your child construct knowledge? Constructing knowledge requires that children build on what they already know. To do this, children must individuate concepts out of continuous experience. They must put those concepts together into models that help explain small pieces of the world. Children must then test these models to find situations in which the models do not explain experience. By model testing, they must learn new concepts that can help them to build new models. They must do this over and over again for many models. I call this process *the curiosity cycle*. A diagram of the curiosity cycle is shown in Figure 1.1.

Individuating Concepts

The first step to constructing knowledge is individuating concepts from the environment. Individuating concepts requires pulling cohesive pieces out of the continuous whole of experience. This process is so automatic that we don't realize we are constantly doing it. It feels like the concepts are just there to be seen, but this is not the case. Previously, I mentioned the example of trees. Consider another example: My wife and I were in a room, and she pointed out that the crown molding was beautiful. At that moment, I realized that I had never seen a crown molding before. I had heard the term "crown molding," and surely my eyes had pointed in the direction of crown moldings before, but I had never before noticed it as a concept. And more important, I had never noticed that I hadn't noticed crown moldings. I didn't look at

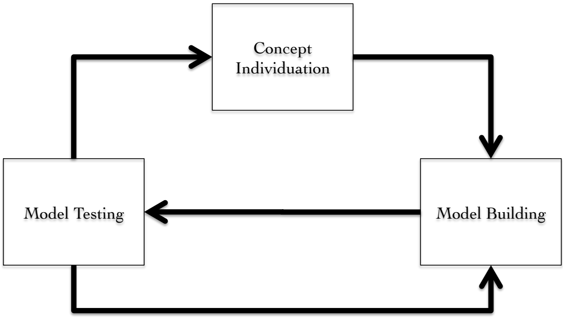

Figure 1.1: The Curiosity Cycle. Children individuate concepts from the environment, and they use these concepts to build models. They can then test these models to see how well they predict the environment. Through this process of testing, children will learn new models and concepts leading to the next round of the cycle. Their natural curiosity makes the cycle go around, and the cycle also adds to their curiosity.

the top of a wall and think to myself that I didn't know what that thing was up there, it just didn't exist for me.

These elements and ideas that we individuate are *concepts*. A concept is something that you can think about consciously. A concept can be a person, place, thing, or idea. A chair is a concept. Talking loudly is a concept. Color is a concept. A concept can also be a feature of something such as "large" or "round" or "loud" or "heavy." A concept can also be a category such as "dog." We perceive the world in terms of concepts.

Putting Concepts Together into a Model

The next step is for your child to put the individuated concepts together into a *model*. A model is a linking of concepts into an understanding of how a small piece of the world works. Models can be used to predict the future, such as predicting that a certain person will talk loudly. Models can be causal models that show how the world changes. For example, consider an electric circuit with a switch, a light bulb, and a battery. Flipping the switch to close the circuit causes the electricity to run through the wire and light up the bulb. This is a causal model because we see that if you cut the wire, the light bulb will go off. Models can also be observed patterns that may predict the future, but the learner does not understand why. For instance, in the late 1980s, rolling up your blue jeans in a certain way was correlated with being cool. I have no idea why.

Models are made from concepts. For the crown molding example, once the crown molding feature has been learned, your child can learn a model that says that if a building has crown molding, then the building is fancy or nice or old. But without having the concept of crown molding, your child can't build that model. Once a set of concepts is individuated, your child's natural model-building process can take over. If your child pays attention and has a desire to predict events, the models will emerge.

Testing the Model

When your child has a model, it can be tested in the world. The great thing about the world is that if you ask it the right question, it will tell you if your proposed answer is right or wrong. This means that when children have a model that links together concepts, they can look to see if these concepts are really linked in that way by observing events in the world. This answer allows children to refine the model or to individuate new concepts.

For example, there is an old joke that goes like this: What does “La Quinta” mean in Spanish? Answer: “Next to Denny’s.” You might initially have a model specifying that Denny’s restaurants are located near hotels. This model might be pretty accurate, but it will still often fail. You will often see a hotel but not see a Denny’s next to it. But since you like Denny’s (just go with me on this one) you try to make the model more reliable. One day, you notice that Denny’s restaurants are more likely to be located next to a particular kind of hotel named La Quinta. Once you notice this type of hotel, you can identify it and find Denny’s restaurants with increased reliability. By doing this, not only have you made your model more reliable, but you have learned the new concept that there is this particular kind of hotel called La Quinta. Just like with the trees, before you learned the concept you only saw a generic hotel. Maybe you only knew about four kinds of hotels, and your brain just mapped all others to “hotel.” But now, La Quinta will be on your radar, and you will know five kinds of hotels.

Constructing a Web of Knowledge

The curiosity cycle allows your child to construct a *web of knowledge*. This web of knowledge consists of learned concepts and models and contains what your child knows about the world. Each piece of knowledge is connected to other pieces of knowledge, creating a web. The curiosity cycle, through the process of individuating concepts, building models, and testing models, is what creates the web of knowledge. Curiosity is what spins the curiosity cycle around, and the process of concept individuation, building models, and testing models adds to curiosity.

Many of these little cycles spin around at once, and cycles build on concepts and models created in previous cycles. Once children learn one thing, they can use that idea in components to learn other things. For example, a child quickly learns that the ringing of the telephone means someone is there waiting to talk. When this child moves into an office environment, the now young adult can build on that concept of ringing to learn that a ringing of the telephone that repeats two short rings indicates an outside call, and a ringing that repeats one long ring means an inside call. This model cannot be learned without first knowing the concept of ringing and then building on that concept to distinguish between repetitions of two short rings and one long ring. Trying to guess who might be calling raises a question that is partially answered by learning to distinguish between these two types of rings.

In the curiosity cycle, even incomplete models are useful. Your child doesn't need a perfect model, just one that can be refined later. An incomplete model or even an incorrect model is better than no model, because once you have formed a hypothesis, then you can test it. But without these little fragments to test, you have nothing.

I say that an incorrect model is better than no model. Now, of course, Mark Twain once said, "It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so." I believe this is true. When it comes to *decisions*, it is important to know that your model may not always be correct and to take that into account. But when it comes to *learning*, an incorrect model can be a useful place to start.

Another implication of the curiosity cycle is that learning a little about something goes a long way. We have a tendency to avoid learning only a little about a topic, maybe because it makes us feel ignorant. But if we do learn even a little, we will have concepts and partial models that can keep accumulating over time as new information happens to come in. Without these partial models and concepts, we just ignore that incoming information and opportunities for learning are wasted. The result of the curiosity cycle is that the more your child knows, the more curious your child becomes.

1.3 Curiosity-Driven Learning Leads to Supple Thinking

Supple Thinking Is Flexible and Adaptive

Flexible thinking allows your child to use the best approach for the current situation. Adaptive thinking allows your child to use the best pattern of behavior for the longer-term state of the world. These terms overlap, so I use "supple" to describe thinking that can change to fit the situation.

An old story tells about a group of people in India who would trap monkeys using an emptied-out coconut filled with rice. The coconut had a hole large enough for a monkey to put an open hand into but too small for the monkey to pull its hand out with a fist full of rice. The trappers would attach this coconut to a stake. The monkey would come, put its hand into the coconut, and as the people came to capture it, the monkey would be trapped by its own brittle thinking. Its thinking was not supple enough to reevaluate the situation and realize that it should let the rice go.

Supple thinking will be increasingly important as the rate of change of the world continues to accelerate. New technologies will come and go. And more traditionally, your child will have different teachers and coworkers with different expectations to adapt to. Additionally, your child will need different approaches to problems in different situations. Some situations will call for quick action, and others will require a wait-and-see approach. Sometimes your child may need to be a leader, and other times your child may need to be conciliatory. Even different games require different approaches. As we will see in Part III, when playing Tic-Tac-Toe your child should consider all possibilities before each move, but in chess this is impossible and a different approach is needed.

Supple Thinking Comes from Knowledge That Is Deep and Tentative

Supple thinking requires children to not just blindly follow previously learned thought and behavior patterns, but to actively relate incoming information to everything else that they know. Additionally, children must always be aware that some of what they know could be wrong—probably is.

By learning through the curiosity cycle, new ideas become deeply embedded in the knowledge that your child already has. Curiosity leads to deep understanding because your child doesn't just know facts by rote; your child has models for why things are true and sees the relations to everything else that he or she knows. These models can then be changed or adapted when the situation changes. For example, assume that x stands for the value of something in the environment that we care about, and let's say that your child and another child both know that $x = 8$. The other child has a shallow understanding and just has it memorized that $x = 8$. But if your child has a deeper understanding, he or she will have a model that determines where the value of x comes from, such as the simple model of $x = y + 3$. Imagine that normally, $y = 5$, but your child notices that y has increased by 1. Your child will instantly know that $x = 9$, but the other child will still think that $x = 8$.

Being curious also means that your child is always on the lookout for a better model. If the world changes and the model $x = y + 3$ no longer holds on Tuesdays, and now, on Tuesday, $x = y + 4$, your child will notice and adapt.

As a more concrete example of how supple thinking allows your child to predict the future when the future is different than the past, I once took a linear algebra class in which everyone had done well on all of the tests leading up to the final exam. Based only on previous experience, you would conclude that the final exam was going to be easy as well. But, by relating this information to other information, you know that not everyone can receive an A, and that the professor needs a separation of grades. Using this understanding, you come to the opposite conclusion: Since currently everyone is doing well in the class, and since there isn't much separation in the grades, the final exam will be especially difficult. It was.

Beyond linking knowledge to everything else your child knows, your child should view knowledge as tentative.

Knowing that you might be wrong is the first step toward undoing an assumption and finding the right solution to a problem. Considering knowledge to be tentative cuts down on mistakes from not realizing that things could be another way. It leaves your child open to learning new things, and this can continue throughout life.

1.4 Curiosity-Driven Learning Makes Life Interesting

Building the way you see the world makes life interesting. We have seen that learning about the existence of crown moldings and about different types of trees creates concepts that determine how you perceive the world. We are curious about what we know, so the more we know, the more curious we become. However, the curiosity cycle is more than a method for facilitating learning, it can make life more rewarding for your child.

Everything in Its Right Place

Curiosity-driven learning makes learning more interesting because your child has a place to put new facts. Your child doesn't have to try to remember a bunch of unrelated ideas; everything fits together and is linked to what he or she already knows. This is good because memorization is boring. It is easier to integrate new information when that information "makes sense" based on the concepts and models that your child already has.

To illustrate this point, consider the old experiment where both experienced players and novices were shown chess boards with chess pieces on them, and both groups were asked to later remember the locations of all of the pieces. Experts performed better at remembering the locations of the pieces, presumably because they understood what they saw using their web of knowledge about chess. Interestingly, there was no difference between the groups in ability to recall piece locations when the experiment used chess boards that were not from actual games (that is, when the pieces were just randomly placed on the board). In this case, the experts could not use their web of knowledge to interpret what they saw.

Your Child Makes Little Bets

Each model that your child creates is like a little bet on how the world works, and these little bets keep life interesting. People who play fantasy football say that it adds another dimension to watching football games. You make a bet (by choosing who is on your fantasy team) and then see how it plays out. These bets are often practical as well as interesting, and air travel is one area where people enjoy pondering the many mysteries. For example, having an open seat next to me on flights is important so I can be comfortable and productive. I created a model that there are more open seats in the back of the plane because people generally prefer to sit up front to exit the plane faster. To test this model, I started sitting in back and found that indeed it does seem to improve the probability of having extra work space.

Curiosity Lets Your Child Be Free

Curiosity-based learning is internally directed and intrinsically motivated. We achieve a sense of freedom from living this way. In school, your child will actually care about the subject being taught. Because the curiosity cycle is running, your child will want to use the subject material to help complete some of his or her models, much like a baseball card collector wants to complete a set. And because of this curiosity, it won't feel like work. Your child will feel like a free and natural human being doing what he or she wants to do.