

Scientific Revolution and Education

How Re-visiting Thomas Kuhn’s “*The Structure of Scientific Revolution*” can point us to the education of tomorrow

By Marc Prensky

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[Original publisher's note: “Marc Prensky is the kind of person who may someday be able to claim to have made a material change, for the better, in this system.... he is brilliant, dedicated to truth, and will not give up. In this [piece you] will discover someone who deeply understands basic education, knows its patriotic and financial value to the country, and is willing to keep working on improving it. What could matter more?” – Mark R. Anderson.]

“When the transition is complete, the profession will have changed its view of the field, its methods, and its goals.”

– Thomas Kuhn

The terms “paradigm” and “paradigm shift” are on the keyboards and lips of a great many who write and speak about education these days. Has a paradigm shift in education really taken place? We can get some answers by going back to the book where the terms originated.

In 1964, Thomas S. Kuhn, a scientific philosopher and historian at U.C. Berkeley, who later went on to work at Harvard and Princeton, published a monograph in the *International Encyclopedia of Unified Science* titled *The Structure of Scientific Revolution*. Soon after, it was published as a book by the University of Chicago. Kuhn’s original thinking and perspective, groundbreaking in its time, sparked intense debates and conversations in the scientific community. Today, more than half a century later, the book is still considered an important and fundamental contribution to our understanding of how science works and progresses.

In this essay I consider whether and how Kuhn’s work—and his original model for how scientific revolutions take place—apply to what is happening in education today, circa 2018. In re-reading the book (which I first read in college over 50 years ago) my reaction was that it does strongly enlighten issues that, I believe, are currently very hard for many people—including educators, parents, politicians, and even kids—to understand.

Among these are: Can we explain why our education no longer works as we want it to? Can we fix it, or do we need something new to replace it? And how might such a replacement happen, given all the resistance we see?

Prologue: Education Today

Today, almost everyone can see the world rapidly changing. And many, if not most, would agree that education, throughout the world, is struggling to keep up.

What educators, employers, parents and kids are finding, almost everywhere, is that the kind of “academic” education that worked so well for decades—and opened so many doors for so many people—is no longer doing the job it once did. Despite the continued testimonies to its value by their elders, more and more kids find the education they are given in school irrelevant to their future (and present) lives, don’t like it, tune out or drop out. Parents search frantically and often in vain for “better” education and schools for their kids. Countries and politicians make system-wide reforms.

Yet while everyone is busy trying to improve education, few, if any, school systems or districts—or countries—know precisely how to do it, or even what directions to go in to make it better. They hear from pundits around the world that “our industrial-era needs are changing,” but they are given a surprisingly narrow list of new options—mostly lists of new things to add. Their responses—often developed with long deliberations and billed to the public as big “education reforms”—consist almost entirely of tinkering at the margins of their current systems by adding “modern-sounding” things like “innovation,” “creativity,” “21st century skills,” “STEM” and “STEAM” classes, “social/emotional skills,” and other things to their current offerings. They try to “raise standards” and spend a ton of money on new technologies—primarily to teach the old “core” curriculum of math, language, science and social studies which has hardly changed, to all. Although perhaps giving the appearance of progress, this “tinkering” approach does not really address the deeper, underlying causes of our educational malaise—and is therefore unlikely to work.

Our View of Kids

What is that underlying cause? No matter what system changes the reformers make, or what changes they add, one thing almost always remains the same—***their view of who our young people are and what they can do.*** Reformers—like most adults who have gone through school in their youth—see today’s students as *they* were at that stage of life, i.e. as powerless beings who need to be “educated” by adults according to an adult-designed plan, before they can function in the adult world. Almost all the practitioners of our current education—the education that, in one form or another currently dominates the entire world—share this common, unstated, underlying assumption: that our kids enter school unable to accomplish anything; that we the adults must and can

figure out what instruction to give all of them; and that our teachers should be re-trained to deliver whatever newly reformed program the adults decide is best. The reformers—again, like most adults—concur in the belief that the goal of education is to make young people into “better” individuals—better, that is, at a limited range of (mostly intellectual) subjects and skills—and that the way to do this is to have our kids spend years in classrooms, learning content, taking tests, and earning rankings & degrees.

The Emerging Alternative

“Every country on earth, at the moment, is reforming public education”, says Sir Ken Robinson, a well-known education speaker and author. Yet while all this time-consuming and often quite expensive “reform” is going on top-down, another, very different perspective on education is emerging, bottom-up, in small pockets all over the globe. It varies from place to place in its particulars but is remarkably similar in its overall approach.

This “new” kind of education is based on a very different view of kids on the part of its practitioners—that today’s young people are far more empowered—partly by technology, but also by the times in which they are growing up. They see kids as being able to do many useful things immediately, and not having to sit through a decade of classes before they can contribute to the adult world. These practitioners believe that the education today’s kids need is not just “learning” in preparation for an uncertain future, but rather the continuous challenge of world-improving projects and real-world accomplishment so that kids know how to get things done. These practitioners see much of the content that current educators often call “basic” and “necessary” as irrelevant. They are busy designing new processes, different challenges, new combinations of skills—i.e. new ways of becoming “educated”—to prepare these newly-empowered kids for whatever comes their way in the 21st century and beyond. They are helping kids search for their own unique combination of interests, strengths and passions, and helping the kids understand how to apply those to the real world. They are replacing prescribed curricula for all with custom-designed educations. They link education far more closely to the communities in which kids live, and to bettering world the students live in.

Unlike the current education—with or without the reforms—wherever this new type of education is offered—as it now is by a smattering of schools, teachers and programs all over the world— it is a process that today’s kids enjoy and thrive on. It is an education kids *want* to get—because it is designed with kids’ dreams, and not just adults’ desires for the kids, in mind.

The essence of this new education is a new way of seeing our kids—viewing them as increasingly empowered people who can, and should, better their own world today. Its

buds are emerging all over the globe. But will a worldwide transition to this new and better kind of education actually happen? And how?

No one knows for sure. But it turns out that, thanks to Thomas Kuhn, we do have some guidance—and a possible roadmap.

Part I: The Structure of Scientific Revolution and Kuhn's concept of Paradigm Shift

In his book *The Structure of Scientific Revolution*, Thomas Kuhn considers the process by which, from time to time, mainstream scientific thinking radically changes direction. Kuhn proposes a model and framework for how such major shifts in scientific thinking and practice have happened—e.g. the shifts from the Ptolemaic to the Copernican view of the world, or from the Newtonian to the Einsteinian—each extremely different than what came before—have occurred. Kuhn proposes that rather than science just being a continuous, linear progression of discovery and thought, there is a “periodic” progression from one view of the world to another incompatible one. Science, Kuhn says, moves from one period of “normal” behavior to another—i.e. from one “paradigm” to a “new paradigm.” Further, Kuhn describes how these transitions typically occur, and their accompanying crises and disruptions.

Although in a later postscript to his original publication Kuhn mentions briefly that his model of scientific change has been applied by others to fields outside of science, including philosophy, sociology, economics and political science, he does not in this book mention education specifically as a field to which his theories might apply. Yet many have since applied if not Kuhn's exact theories Kuhn's terms of “paradigm” and “paradigm change” to education. Still, although educators today use, with great frequency, these terms Kuhn coined, I am not convinced that Kuhn's original ideas, perspectives and model have yet been accurately applied to education. Kuhn's model has a lot to teach us, I believe, about what is currently going on around the world in the education field.

So I will try to add my own perspective here. My plan here is to first describe what I see as the key elements of Kuhn's original thesis and model—using as much as possible his own words—and then suggest the implications for education, today and tomorrow.

1. Kuhn's Concept of “Paradigms”

In elaborating his explanation of how and why changes in scientific thinking happen, Kuhn uses the key term “paradigm.” As some have pointed out, he uses the term, throughout the book, in multiple ways. Of these uses—and unlike, I believe, for many others who have since adopted this term—for me what is most useful is when Kuhn

defines a paradigm not just as a set of currently-widely-accepted practices, but rather as ***the set of common assumptions*** on which those practices are founded.

In Kuhn's words, a paradigm is "a collective way practitioners look at the world." Importantly, for Kuhn, a "paradigm is not about facts, or behaviors, but about *perspective*. It governs "...not a subject matter but rather a group of practitioners." So a paradigm, for Kuhn is not what people do, ***but rather how they perceive the world which causes them to act in that way***. This is, I think, often missed.

The currently prevailing paradigm—i.e. most practitioners' shared view of the world around them—in turn defines, according to Kuhn, the kind of work practitioners are permitted and expected to do. Such work, i.e. the work that happens within the confines of a prevailing shared paradigm, Kuhn refers to as "normal science." For Kuhn "Normal" for Kuhn does not mean "ordinary," but rather "falling within the norms of the then-prevailing paradigm." This prevailing paradigm defines, writes Kuhn, "the kinds of behaviors and practices declared to be acceptable," by the practitioner group, and so normal means what most practitioners think it is right and proper to do. This includes, importantly, many types of innovation.

There are, however, practices and activities deemed by the group to be outside the current paradigm, or collective view of the world. According to Kuhn, these are, typically rejected by the community of practitioners as "unworthy of pursuit"—and the practitioners are shunned. When the prevailing paradigm and commonly accepted view of scientists was that one element could never be changed into another, for example, any work that tried to do so—such as alchemy—was considered "outside of science." But later, when the prevailing paradigm had changed to a world in which atoms and elements could be fused and split, the pursuit of changing one element into another was re-legitimized (albeit with new approaches).

2. How Paradigms Change—The "Kuhnian" Model

Kuhn uses the phrase "paradigm shift" to describe a major change in perspective on the world on the part of practitioners. His model for how paradigms change and evolve is simple in its overall structure. Many call it "periodic." Kuhn proposes that there are long periods in history during which the group of practitioners in a field does its work within the confines of a common understanding, or "paradigm," of how the world operates (i.e. periods of "normal" science). Within each particular paradigm, the science advances "normally," via an accumulation of new experiments and practices, all answering questions the paradigm deems worthy of consideration. This leads to refinements, but it also typically leads to, and includes, many advances in the field, and in scientists' understanding of the world (within the paradigm).

3. “Anomalies”

However from time to time, posits Kuhn, results, events and problems arise that the prevailing “normal” science — no matter how much scientists try to twist and turn it—cannot adequately account for, or address. These events and problems—things not producing the results expected by the paradigm’s theories, are what Kuhn calls “anomalies.”

“All is well,” says the author of Kuhn’s introduction, “until the methods legitimated by the paradigm cannot cope with a cluster of [such] anomalies...”

When the prevailing paradigm was that the planets all revolve around the earth, for example, as the Ptolemaic astronomers’ measurement accuracy gradually increased, their theories could not accurately account for the actual movements observed, no matter how many sub-orbits they added to planets’ theoretical orbits. Yet evidence of anomaly had to build up for a new perspective, contrary to the established order, to take hold.

4. Kuhnian Crisis

But, if severe and persistent enough, such anomalies, posits Kuhn, eventually lead to what he calls a “crisis” in the science involved. As the book’s introduction-writer writes, “Crisis results. Anomalies become intractable. No amount of tinkering will fit them into established [practice].”

Such crises, says Kuhn, “simultaneously loosen the stereotypes and provides the incremental data necessary for a fundamental paradigm shift.” And, as Kuhn observes, “typically, during the crisis period, individuals arise with new and different perspectives on the world—i.e. different paradigms.” In fact, Kuhn argues, “crises are a necessary precondition for the emergence of novel theories.”

During each so-called “Kuhnian crisis” the body of scientists, once more or less united in its view of the world it is dealing with, starts to fracture: these are the periods of Kuhn’s “scientific revolutions.” “At [those points],” Kuhn writes, practitioners are “divided into competing camps or parties, one seeking to defend the old institutional constellation, the others seeking to institute some new one.”

Kuhn is at great pains, however, to explain that the “new,” competing world-views that emerge from a scientific crisis are necessarily “right” in any absolute sense. What they are better at, though, is dealing with particular kinds of problems which have suddenly become very important. “Paradigms gain their status” Kuhn writes, “because they are more successful than their competitors in solving a few problems that the group of practitioners has come to recognize as acute,” writes Kuhn.

During the crisis periods, practitioners, try hard to convince each other that their view of the world—whether the old view or a new one—is a “better” view to hold. Because “better” cannot, Kuhn believes, be proved in any absolute sense, this is typically difficult. So, he writes, “the parties to a revolutionary conflict must finally resort to the techniques of mass persuasion.”

In Kuhn’s model of paradigm change, one of these revolutionary perspectives eventually gathers more practitioner/adherents than others, and gradually becomes more popular than the others among the body of practitioners. When a new view of the world has won the allegiance of enough of them, there follows a long transition period in which practitioners shift over to the new paradigm. During this period, many, if not most supporters of the old paradigm feel to some degree threatened, and some never make the transition. Writes Kuhn: “the new theory implies a change in the rules governing the prior practice of normal science. Inevitably, therefore, it reflects upon much scientific work they have already successfully completed. Its assimilation requires the reconstruction of prior theory and the re-evaluation of prior fact, an intrinsically revolutionary process.”

Therefore, Kuhn writes, “at times of revolution, when the normal-scientific tradition changes, the scientist’s perception of his environment must be re-educated—in some familiar situations he must learn to see a new gestalt.” “It is a good sign,” says Kuhn, “if the new paradigm permits the prediction of phenomena that had been entirely unsuspected while the old one prevailed.” Because it requires re-education of practitioners, scientific revolution, and paradigm change, says Kuhn, “is seldom completed by a single man and never overnight.”

But once enough practitioners have shifted to the new paradigm, a new period of “normal” science begins—and endures until the next anomaly occurs. In the end, “an older paradigm,” writes Kuhn “is replaced in whole or in part by an incompatible new one.” “When the transition is complete,” Kuhn tells us, “the profession will have changed its view of the field, its methods, and its goals.”

Kuhn also emphasizes that the old paradigm and the new one are almost always incompatible—“incommensurate” is the term Kuhn uses—a practitioner cannot subscribe to the old and the new simultaneously. Therefore, when scientific revolutions occur, typically practitioners **must change paradigms to remain in the field**. (Although there are always some who remain unconvinced and never change their views—Kuhn gives the examples of scientists not accepting Darwin’s ideas or Planck’s.)

The Heart of the Change

It cannot be over-emphasized that at the very heart of Kuhn's process of paradigm shift is ***a change in the way practitioners see the world***. In fact, I believe Kuhn's key insight is ***that these paradigm shifts represent a move to a very different way of practitioners viewing and thinking about the world in front of them and about their practice within it***. That is why paradigm shifts are revolutionary. Kuhn says this again and again, in a variety of ways

"neural reprogramming ..., however inscrutable at this time, must underlie conversion."

"The conversion experience, that I have likened to a Gestalt switch, remains, therefore, at the heart of the revolutionary process."

"the ... revolution is a displacement of the conceptual network through which [practitioners] view the world."

"What a [scientist] sees depends both upon what he looks at and also upon what his previous visual-conceptual experience has taught him to see"

"During revolutions scientists see new and different things when looking with familiar instruments in places they have looked before."

"the scientist who embraces a new paradigm is like the man wearing inverting lenses [...who has...] undergone a revolutionary transformation of vision."

"familiar objects are seen in a different light...[there is] a switch in visual gestalt"

"[after a revolution] the scientist works in a different world."

Kuhn also strongly emphasizes how difficult it is for the people on either side of the paradigm change to communicate and persuade each other:

"Practicing in different worlds, the two groups of scientists see different things when they look from the same point in the same direction."

"Neither side will grant all the non-empirical assumptions that the other needs in order to make its case...they are bound partly to talk through each other."

“Communication across the revolutionary divide is inevitably partial...Schools guided by different paradigms are always slightly at cross-purposes.”

“The competition between paradigms is not the sort of battle that can be resolved by proofs... neither proof nor error is at issue.”

“[something] that cannot even be demonstrated to one group of scientists may occasionally seem intuitively obvious to another.”

“A decision between alternate ways of practicing science is called for, and in the circumstances that decision must be based less on past achievement than on future promise.”

“Before they can hope to communicate fully, one group or the other must experience the conversion that we have been calling a paradigm shift.”

“The transition between competing paradigms cannot be made a step at a time, forced by logic and neutral experience.”

“The man who embraces a new paradigm at an early stage must often do so in defiance of the evidence provided by problem-solving.”

“the superiority of one theory to another is something that cannot be *proved* in the debate. Instead, I have insisted, each party must try, by persuasion, to convert the other.”

“The proponents of competing paradigms practice their trades in different worlds.” “[the] debate is about premises.”

“How, then, are scientists brought to make this transposition? Part of the answer is that they are very often not.”

Finally, because they see their world differently after the revolution is complete, practitioners *do* different things:

“After a scientific revolution” Kuhn writes, “many old measurements and manipulations become irrelevant and are replaced by others instead.”

Applying Kuhn's ideas of Paradigm Shift to Education

With Kuhn's words and model of scientific change in mind, let us now consider how it might inform us about education today and tomorrow in the world.

In the final chapter of his book, Kuhn himself suggests that his "periodic" model of paradigm shifts in science exists in other fields as well, mentioning, for example, how art moves through "periods"—i.e. times where new styles are considered appropriate, and older styles not. But Kuhn never addresses education specifically.

So how can he enlighten us here?

"Normal Education"

The first helpful idea I found was Kuhn's concept of "normal science," i.e. the kind of practice that goes on between paradigm shifts. Might there be there such a thing as "normal education"?

I believe there is, and that the world has been going through—for the past several centuries at least—what, in Kuhn's terms, is a long period of such "normal" education, based on a particular, and specific worldview. During that period, practically the entire world, has come together in a common, prevailing understanding of certain things. Among the most important are (1) what the students sitting before them in class can and should be doing at particular ages, (2) what an "education" means for those students, and (3) as a result, what is appropriate and "right" for educational practitioners to be doing to and for them.

"Helpless," Unempowered Kids

One way I describe this currently-prevailing view of the world is the "helpless kids," or "our young people need to be instructed for many years before they can contribute" paradigm of education. It has been with us for so long that many have come to think that "instruction" is all that "education" is, or ever could be.

But it is only, as Kuhn describes, a "period." We know this because before this current view of the world, or paradigm, took hold there was, for millennia, another prevailing worldview—the paradigm that "kids can start work early and pick up what they need from imitating their parents (or, if apprenticed, from imitating their master)." And even though our current view has prevailed for some time, we can expect, as more and more anomalies occur, to have, a different paradigm, and a different education, in the future.

Results

The results of our currently prevailing paradigm and view of the world and our kids are the educational practices now considered “acceptable” in the world — including grouping our kids in classrooms by age and subject, having a single teacher in each classroom delivering—in his or her own way—a curriculum that has been decided and provided centrally, and administering periodic examinations and tests to students, “ranking” the students in order of their scores and progress.

Yet it is crucial that we continually remind ourselves that this now near-universal view of what an “education” consists of—and the systems and behaviors that are “appropriate” for educators —is based on a particular way of looking at and seeing the world, and, in particular, the young people we are trying to educate. In Kuhn’s terms, it is based on our viewing our kids through a particular “set of lenses.”

The lenses through which educators (and as a result, parents) have viewed our kids for several centuries, if not millennia—has been that ***young people are essentially helpless and powerless and need to be instructed, for many years, in both content and skills, by professional teachers, before they can become productive, useful, contributors, workers, citizens and people.***

It is to do this necessary “instruction” that we have established a common set of behaviors, creating schools—similar throughout the world—where teachers in classrooms deliver material and assignments to groups of kids, and evaluate and rank kids on their progress in “learning” the material—mostly through testing.

This is not the only kind of “education” we could give our kids, but today, it is what most of the world believes “education”—and therefore the educational practitioners it hires—are supposed to do. They are supposed to instruct our kids systematically, in advance, on what their elders consider important to know, and to be able to do. The instruction can certainly be delivered in a variety of ways. But any “education” that does not do this—such as the so-called “unschooling” movement, for example—falls outside our current “normal” paradigm, and most practitioners dismiss it as not a valid educational practice. We should remind ourselves though that, according to Kuhn, a paradigm is neither “right,” “wrong,” “good” or “bad” in any absolute sense, and that this applies to our current paradigm of education—i.e. how we see our kids and what we do as a result.

But it works!

It is true that the world’s current education has worked well, for a long time, in many places. The people who went through it became, in many cases, intellectual leaders, and capable citizens and industrial workers (although we have little proof that this is

because of, or in spite of, the system.) Moreover, the paradigm's key assumption that "kids are helpless and need to be instructed" fits with the world as many, or most, have perceived it.

And the education under the current paradigm has not, despite what some claim, remained the same over this time. Education has changed in many ways over the past several hundred years, with numerous instances of evolution and progress within this view of the world. This is what Kuhn would call the "normal" evolution of the field. We have seen the introduction of hundreds of new techniques, tools, and technologies: over the last several hundred years, including improving the core curricula of math, science and social studies, adding additional subjects such as arts and social-emotional skills, reducing class size, adopting higher standards and "competencies," adding new technology—all of which have made the current-paradigm-based education better and more successful. All of these many "educational innovations" are acceptable under the prevailing education paradigm (i.e. our current view of kids), and most are accepted by practitioners. Certainly, those practitioners who create and implement these innovations see themselves, and education, as "making progress." What has NOT changed, however, in quite some time, is the still-prevailing view of the world and of our kids that young people are helpless and need to be instructed before they can contribute.

Part II: Why Today's Education Won't Work in the Future

The "anomaly," that underlies our need for civilization-level educational change, and the emerging battle it has produced.

Today all is not well in the world's educational system—as Sir Ken reminds us, people everywhere are trying to "fix" it. Yet problems have begun to occur within our education that cannot easily be fixed—no how much we try to "innovate" around them. I believe we have begun to see, and recognize, what Kuhn would call "anomalies" in our education. The most important anomaly is that the same kinds of educational activities, programs and procedures that have been successful for a long time no longer produce the same results—even when we try to "update" them. The value of the formal education we give our kids—so long held in high esteem and important for anyone who could get it—has more and more come into question, despite the well-known statistics showing that more education has, in the past, led to higher incomes (our proxy for "success"). A great many are wondering why this is happening. So what can Kuhn tell us?

Remember that paradigms are, according to Kuhn, essentially practitioners' views and assumptions about the world, and the practices those lead to. The reason behind our problems, I submit, is that ***our paradigm's key assumption is no longer valid: our***

fundamental view of our kids that underlies and validates our long-time “normal” education perspectives and practices—that our young people are helpless—is no longer the case. Today, more and more kids have become, and all are increasingly becoming, empowered by the tools and culture of the 21st century—they have radical new capabilities, and aspirations, that people didn’t have at their age in the past. Today’s young people are empowered both by the evolving technologies and evolving attitudes and culture of our changing world, and that empowerment, although not yet everywhere, is both accelerating, and, at varying rates, spreading to all kids. A large and quickly growing number of our kids are not the same people that today’s adults were at that age— they are no longer the people that “normal” education was designed for.

Here we should note an important difference from the precise model Kuhn proposes. In Kuhn’s model of scientific revolution and paradigm change, the world stays the same, but practitioner’s perspectives (i.e. “lenses”) on that world change. In education today, the world has actually changed—kids have become empowered.

Yet practitioners still need to change their lenses—formed in an earlier age—to see it, although a better analogy might be that practitioner’s lenses need to be cleaned. And if they were, what today’s teachers would see sitting in front of them when they looked out at their classes is not just individual young people, as in the past. More and more, they would see—once their lenses are clean—young people with radically **extended brains, all networked together.**

They would see that today, students—of all ages—are capable of, and are doing, things that people their age have never been able to do before: invent things, design things, fix things, discover things, and more. For example,

- Primary school kids in India wanted to add traditional crafts to their curriculum. They taught themselves the crafts and then sold them to get additional funds for their school.
- College students in Denmark created an App to alert people online whenever garbage bins were full or needed maintenance, that was implemented by the local government.
- High school students in California grew tired of waiting after numerous failed attempts by school administrators to control a large cockroach infestation at their school, and started a Facebook page and public group to pressure school administration for more action.
- High school students in Singapore who wanted to reduce unnecessary waste in their community advocated against the use of Styrofoam cups and plates through campaigns, talks, skits and flash mobs, and got them banned at their school.

- Kindergarteners in France taught the senior citizens at a local old-age home how to operate iPads in exchange for reading and writing tutoring.
- High schoolers in Texas designed and prototyped a complex robotics system to clean and maintain the world's largest radio-telescope.
- A first grader in Canada learned that parts of Africa lacked clean water started a foundation to dig wells.
- A fourth grade class in Missouri responding to a "Request for proposal" for a new waterpark, formed teams to design the waterpark to their own needs, lobbied the city council, and ultimately got their ideas Incorporated into the plans of the architectural firm that was awarded the contract.
- A U. S. 5th grader, frustrated about being given books she couldn't relate to at school, set a goal to collect 1000 "Black girl books" by the following February—and collected over 4000, and created the now widespread "#1000blackgirlbooks" campaign.
- High schoolers in NY created an app to help people who suffer from depression by giving them tips on improving their mood.
- High schoolers in San Francisco transformed their school into a multimedia museum dedicated to the memory and lessons of the Holocaust.
- An 11-year-old reacted to the water crisis in Flint, Michigan by building a sensor and app system that reliably detects lead in water far more quickly and cheaply than existing systems.
- A 15-year-old designed a 3-cent test for pancreatic cancer that finds it earlier and is 100 percent accurate.
- A 17-year old researched, developed and tested a global neural network cloud service that is able to detect 99% of life threatening breast cancer tumors.
- 11-year-olds in Texas identified the "trap houses" in their neighborhood where drugs were being sold and worked with police to get them shut down.
- High schoolers doing investigative journalism at a school newspaper in Kansas, questioned their newly hired principal's credentials, forcing her to resign.
- Students in South Africa replaces their wetlands flower garden with small vegetable gardens, protecting the wetlands and feeding students
- A high schooler in the US created an App that allows students bullied at lunch to reserve a seat at a safe, welcoming lunchroom table.
- Students in Pakistan concerned about the issue of child abuse created a campaign of sharing children's stories to promote public discussion of the topic throughout their community.
- 15-year-olds in India taught gardening activities to the elderly, helping give seniors' lives meaning and dignity.
- A 14-year old created an App that uses AI and facial recognition technology to help Alzheimer's patients recognize their loved ones.

- 11-year-olds in Taiwan helped immigrant children better integrate into their country and culture by teaching them about Taiwanese rituals, and creating a newsletter with important cultural information.
- Students in India who found there were many problems regarding menstrual hygiene among rural women yet discussing them was a big taboo, consulted gynecologists, collected material for pads and developed workshops to teach women about good practices.
- Kindergarteners who interviewed neighborhood store owners and heard that the owners wanted kids to be more polite, began work to change to other kids' behavior.

These examples are all taken from a database with over 100 real-world student projects from all over the world, available online at btwdatabase.org.

This is new, and VERY different. Calling it an “anomaly” is probably understating the magnitude of the change.

In more and more places in the world, our “normal” education of the past hundreds of years is not preparing our newly-empowered students for their future as our education used to do—even with all the “improvements” places are currently adding. We see evidence of this in school dropout rates rising, in the growing dissatisfaction with school on the part of kids and parents, in kids admitted to college not finishing, in employers not happy with the applicants they get, and in the many school graduates still living with their parents and struggling to find employment. And, of course, we see it in the many attempts to “reforming” education around the world. So, using Kuhn as our guide and map, what can we expect to happen?

Our Kuhnian “Educational Crisis”

The anomalies we are now experiencing in education have led us, I believe, to a “Kuhnian crisis”—the world’s education today is going through precisely one of the crisis periods Kuhn describes. This is the stage in Kuhn’s model, remember, where consensus breaks down on how to proceed, where novel and competing alternative approaches appear and vie with each other for general acceptance, and where new, alternative theories begin to gain practitioners’ allegiance. At this stage, says Kuhn, “the [practitioners are] divided into competing camps or parties, one seeking to defend the old institutional constellation, the others seeking to institute some new one.” We can certainly observe this in the educational world today.

On one side we have the defenders of the old paradigm—educators pushing for raising standards, hiring “better” teachers and creating charter schools that do the “old” education in new ways (or that go back to more traditional ways.) We see pressure

from parents who demand their kids get the same education they got (only better), and who tell educators “Don’t experiment with my kid.” We see growth in tradition-oriented education movements like Steiner schools, and the creation of new, traditional--and costly—private schools such as Avenues.

On the other side, we new initiatives around the world. Some are small and grass-roots. Others, such as AltSchool, XQ, and initiatives at Facebook, Google and Apple in Silicon Valley are funded with millions of dollars from philanthropists and companies. Billions of investment dollars are going into educational startups. Conferences like the annual ASU/GSV draw thousands of attendees. We see new programs that empower kids, like *Design for Change*, expanding rapidly to 66 countries. We see new forms of educational initiatives and institutions—from the Media Arts Center at Palo Alto High in California to the “Concept Schools” in Brazil, to individual provinces in China.

The Kuhnian crisis caused by our newly-empowered kids is being felt around the world by practitioners, parents, politicians and especially by students. “School is not preparing me—it’s irrelevant to my future life,” think (and say), more and more students. “What I am required to teach my kids is not what they need for the future,” think (and say) more and more teachers. “We need to reform the system (or curriculum)” think (and say) more and more politicians. An are wondering and asking “What should I really be doing to prepare my kid?”

Our current crisis stage feels uncomfortable to almost everyone—as it always does according to Kuhn. Kuhn argues, however, that such crises are both good and necessary. “Crises,” he writes, “are a necessary precondition for the emergence of novel theories.”

From Kuhnian Crisis to Paradigm Shift

What else can we learn from Kuhn?

Crisis, in Kuhn’s model, is the stage that precedes a major paradigm shift, i.e. a major transition in how practitioners’ view their world. Crisis is important precisely because it loosens previously strongly held perspectives and biases. “Crisis,” says Kuhn, “simultaneously loosens the stereotypes and provides the incremental data necessary for a fundamental paradigm shift.”

This “loosening” is precisely what we are seeing today. I believe what is beginning to change—in the world and in more and more educators’ minds—is the stereotype of “incapable, unempowered kids.” It is being loosened, principally, by adults’—i.e. parents and educators— observations of what their children and students can now do and are doing. We previously saw a number of examples of this. Here are more:

- Primary students in India, experiencing bad odors in their classrooms and tracing the cause to urine on their feet and clothing, found a way to make inexpensive urinals from old water bottles, and installed them in their bathrooms, eliminating the odor.
- A 12-year-old Illinois student collected over 152,000 signatures supporting banning plastic bags and travelled to the state capital to ask the governor to veto the bill written by the oil lobbyists, which he did.
- Thousands of kids (including primary school kids), in many locations, have contributed contributing to real neuroscience by using the *Eyewire* software game to help map the human brain's connectome.
- High school students are using drones and existing data to monitor marine debris in Alaska.
- High school students from around the world are working with NASA on a worldwide earthquake prediction system.
- Students in India, when historic Ghats were damaged by floods, designed solutions, worked with government, and physically helped in the cleanup, restoration, and preservation.
- Students in Colombia concerned about the disappearance of their community's indigenous language and culture helped preserve it by inviting elders to share their wisdom, starting a curriculum that included the language of their forefathers, and celebrating the main festivals and food of the culture.
- Female students in Benin created programs to keep more girls in school and prevent their families from marrying them off, getting authorities to sign a petition banning forced marriages.
- An 11-year-old student in Texas, concerned about “hot car” deaths, invented and built a device that senses when a car is overly hot and a kid is inside, and blows cool air onto the kid's car seat while notifying parents and police.
- 15-year-old students in India invented a woman’s sandal that stores energy from walking and can deliver an electric shock to a rape perpetrator while sending an alert for assistance to police and family.
- Students in Idaho, alarmed at suicides among their fellow school kids, created programs to help prevent them.
- High school students in California have started and regularly published prize winning hi-end glossy magazines on arts, culture, news and sports for their community.
- Teens in Georgia created an App to rate police encounters and compare local police forces.
- High school students in India, concerned about corporal punishment in schools, designed alternatives and got teachers to change their behavior.
- High School students in Colombia, seeing their rural areas devastated by mining, built a “toy”-sized airplane to reseed those areas.

- High school students in Hawaii traveled to a bombed-out Hawaiian to begin a restoration and healing process.
- A Washington DC 14-year old started a program that has collected, sanitized and re-distributed over half a million used restaurant crayons.
- 21 young people in Colorado, aged 8 to 20, sued the U.S. government for its inaction on climate change.
- High school kids in California, continued the government's important water monitoring program when state ran out of money, using the state-purchased equipment.
- Middle school students in India, who wanted to increase fellow-students' engagement in science, created a "science park" from scrap materials.
- 13-year olds in Colombia created 100 pieces of useful furniture out of old tires and distributed them to the community.
- 8th graders in Ohio discovered a way to convert Styrofoam waste into activated carbon that can be used to filter water.
- 8th graders in California wrote and published a widely praised observation-based nature guide.

What is REALLY going on—the True Paradigm Shift

Today, many apply the term "paradigm shift" to almost any change in educational practices, such as putting students' chairs in a circle for discussions or letting the kids roll their chairs into temporary groups for projects. But for Kuhn, a true paradigm shift occurs at a much deeper and more fundamental level.

Today, while a growing number of educators believe we are not teaching our kids the right skills for the future—which is almost certainly true—they also believe this is "fixable" within our current paradigm—by incrementally adding things, e.g. "project- (or problem-) based learning," "21st century skills," "STEM" and "STEAM" classes, "social/emotional skills," and other things to our current curriculum. This is precisely what many places are already starting to do

But it is not enough. It does not address—even slightly—the anomaly that has led to the Kuhnian Educational Crisis we see today. So it is extremely important that people who care about the future of education not get distracted by the kinds of "reforms" now going on, because from Kuhn's perspective, they are not paradigm changes at all. They are just the "normal" innovations of "normal" education.

These kinds of incremental changes are not part of, or even leading to, a true paradigm shift, because there is almost no change in most practitioners' view of the kids in front of them. No matter how well-meaning and desirous of reform, those practitioners, continue to see kids as helpless and in need of instruction. They just note that today

there are some new things to instruct kids about. ***Their efforts do not address the true Kuhnian crisis, which lies, rather, in the dissonance between what kids can now do and what education asks them to do***—i.e. between the kid’s ability to add value to the world and kinds of activities practitioners are expected, by top-down authorities, to do with their kids. No matter what new subject matter or technology places may add to their programs. ***Teachers are still, in most places, expected to instruct their kids, rather than to empower their kids.***

Different Worlds

Yet I believe that, out of the current crisis, the *truly needed* adaptation of our education—and a true paradigm shift—has already begun. Almost every group of teachers I talk to, throughout the world, feels, and suffers from the dissonance between what kids can now do and what education asks them to do. More and more teachers know, at some level they should be doing different things for their kids, yet they feel they are prevented from treating their kids differently in class—this despite the fact that many tell me they already treat kids differently in after-school programs. I have heard hundreds of teachers express their fear they will lose their jobs were they to do what they believe is right for their kids in their classrooms.

Precisely as Kuhn tells us, “The proponents of competing paradigms practice their trades in different worlds.”

Practitioners of the old paradigm still try to educate kids in a world that still sees the kids as unempowered (which, of course, until quite recently, was the case). Today, though, a growing number of people are seeing the same kids differently, and are practicing their trade in a world of empowered kids. They see the kids in front of them—through their new, cleaner lenses—as already increasingly empowered, and in need of becoming more so through their efforts.

That is the paradigm shift. That is the new way educational practitioners are beginning to see the world.

To shift one’s perspective requires a leap and a conscious choice on the part of practitioners. As Kuhn writes: “A decision between alternate ways of practicing ... is called for, and in the circumstances that decision must be based less on past achievement than on future promise.”

In this case, it’s the promise of kids knowing how, because of their education, to improve their world.

What's Emerging?

Over the last decade I have observed something changing: in pockets around the world some practitioners are beginning to see our young people differently. They are gradually putting on a new set of lenses through which to see our kids. Design for Change talks about “infecting kids with the “I CAN” virus. Ashoka speaks of kids being “changemakers” Writers like Andrew Keen, author of “How to Fix the Future,” talk about “agency.”

This changing view of our kids is as significant and as far reaching in its implications as the Copernican or Einsteinian scientific revolutions that Kuhn analyzed. It is a change in perspective as significant as from thinking the earth is flat to understanding it is round; as major as from thinking the sun revolves around the earth to understanding that the earth revolves around the sun. In the new paradigm educators no longer see their kids as helpless, but instead as empowered to immediately make changes in the world

This new perspective is not emerging “top down” i.e. from the educational establishment, at all—they are focused on the curricular reforms. Rather, it's emerging bottom-up, in more and more practitioners' minds and organizations. Because it has not yet happened in any country as a whole, many haven't yet noticed it. Perhaps some assumed it is included in the curriculum revisions now appearing in various countries. But that's not the case.

What I see emerging—from the bottom up, in pockets all over the globe—is a *much more profound change* than anything any country has done so far. It can be observed, for the moment, only in individual educators, schools and organizations—and only if you look for it, as I have. But It is happening, to some degree *everywhere*. If you do look closely, you will see that the world's education is—in a very profound sense—going through precisely the type of “paradigm shift” that Kuhn describes, i.e. a true change in perspective.

Remember, for Kuhn a paradigm is a *lens for seeing the world*. It provides a particular belief structure within which to advance and innovate. It determines what the body of practitioners think is important to do, build around, and pass on to those entering the profession.

Lots of people—from Mark Zuckerberg to kindergarteners—have now demonstrated that the old paradigm and perspective of “helpless kids” is—in our present and future world—no longer true. As we have seen in many examples, more and more kids know this, and are continuously accomplishing things that demonstrate their empowerment. More and more teachers are beginning to see their students in a new way.

For the moment, the world's mainstream education remains, in Kuhn's terms, deeply in the old paradigm. Even with its many reform initiatives, the world is still in a period of the "old normal" education, "progressing" only by innovating incrementally within the confines of the prevailing world view of unempowered kids.

But that paradigm has now, for a great many, come into question. More and more teachers—the people far closer to the kids than policy makers and administrators—have already put on the new glasses. They see their kids as more empowered—and in need of further empowerment—than as helpless. I have met many of these teachers and educators in countries around the world.

Of course there are also many, particularly those with a lot of time invested in doing things the old way, who feel threatened by their kids' new capabilities. Some will never change their perspective of kids as helpless. In Kuhn's words, the change "reflects upon much [...] of the work they have already successfully completed."

But for those educators who are more open, but haven't yet changed their view of kids, Kuhn offers this advice "At times of revolution, when the normal... tradition changes, the [practitioner's] perception of his environment must be re-educated—in some familiar situations he must learn to see a new gestalt."

That is what I believe is happening. I believe Kuhn's perspective and thinking help us see the current situation for what it is—a sea-change in our perception of our kids, and a new view of the students who sit in front of us. Seeing our young people—our students—as "extended brains all networked together" is very different than viewing them as helpless individuals who have to be instructed in everything.

Today—just as Kuhn predicts in times such as these—"the society is divided into competing camps or parties, one seeking to defend the old institutional constellation, the others seeking to institute some new one." Yet he also reminds us that eventually "an older paradigm is replaced in whole or in part by an incompatible new one."

In the epigraph above, I quote Kuhn as writing "When the transition [to the new paradigm] is complete, the profession will have changed its view of the field, its methods, and its goals." Based on my recent re-reading of *The Structure of Scientific Revolution*, what I expect to happen, is that we will see—sooner perhaps than later—the majority of the world's educators taking a new view of empowered kids, using a new methodology of real-world projects to empower them further, and having a new goal for their students—making their world, through their projects, a better place.

Summary and Conclusion

To summarize, here is what I think we can learn from re-reading *The Structure of Scientific Revolution*:

1. The kind of education we currently offer in the world is not necessarily right or permanent, despite its current ubiquity and universality. It is very much dependent on our currently-held view of helpless kids, and is just a consensus as to what worked in the past.
2. A new paradigm—or view of the world on the part of practitioners—is generally precipitated by an “anomaly,” i.e. something no longer coming out as expected. The anomaly today is that the education we universally offer no longer works as before, because our kids have become empowered.
3. A “true” Kuhnian paradigm change happens not when practitioners “normally” innovate or progress within their current worldview, as is happening, but only when they take a new and different view of the world around them. Despite today’s many reform attempts, the dominant paradigm remains that our kids are unempowered and have to be instructed in everything. Therefore, a true paradigm change has not yet taken place.
4. An “anomaly” that is sufficiently important triggers a “crisis” in a field, leading to new, and often competing, theories. We see this currently, just as Kuhn’s model predicts, in education. The proponents of the existing educational paradigm of helpless kids are fighting hard to protect their views, and to prevent kids from exercising their new power (e.g. through “banning” their devices.) Yet new perspectives are already occurring among educational practitioners. The different camps, as Kuhn predicts, are now trying to persuade each other that their perspective leads to more useful results.
5. In Kuhn’s view of the world, one new view eventually emerges as dominant, and most practitioners switch to it. I believe more and more education practitioners are starting to realize that the emerging paradigm that our empowered kids require a new kind of education—i.e. one based on unleashing our kids’ power to better their world—is far more useful, and that most will eventually switch to that paradigm.
6. The final stage of the “revolution” Kuhn describes is when practitioners make this switch, and the field—i.e. the world’s education—progresses to a new period of “normal” within a more appropriate paradigm— in our case, the paradigm of empowered kids.

The last two stages, of course, have yet to happen. Let us hope, for our kid’s sake, that they happen sooner rather than later.

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