

Maker EDUCATION REVOLUTION

L E A R N I N G

in a high-tech society



PETER DALMARIS, PHD

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Book design by Panos Lampridis

Printed in Australia

First Printing, 2017 ISBN 978-163587122-7

Tech Explorations Publishing
PO Box 22, Berowra 2081 NSW
Australia

www.txplore.com

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Maker Education Revolution

Learning in a high-tech society

Peter Dalmaris, PhD

To Leo and Ari.

You are pioneers in a new world and you have already achieved so much.

I admire you and I love you.

Acknowledgements

There are a few people without whom this book would not have existed. They brutally but fairly critiqued my thinking, questioned my assumptions, challenged my "why", corrected my bad spelling, and supported me along the way. Here, I would like to thank them for all they have done to help me in bringing one more book into the world.

Thank you to my parents Theodore and Despena Dalmaris for providing me with the opportunities to find my creative self as a child.

Dr Ken Dovey, for the mentorship and friendship he gave me as an adult; Ken helped me hone who I am today.

Drew Browne, Andrew Griffiths, Andrea Plawutsky, and David Shirley, for critiquing and helping me fine tune my ideas.

Barbara Albert and Christoph Strizik for their ongoing support.

To my wife Michelle Dalmaris for supporting, challenging me and co-piloting my educational experiments with our offspring.

Of course, special thanks, to Leo and Ari Dalmaris, who have been the willing subjects of my many experiments. Thanks, guys, extra tokens for that!

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*The role of the teacher is to create the conditions
for invention rather than provide ready-made knowledge.*

—Seymour Papert

An Introduction

When I was a kid, my understanding of what technology was revolved around my parent's video cassette recorder and television. TV stations back then would transmit a test card image. This image contained a pattern of boxes, circles and lines that a TV technician would use to fine tune the TV receiver to the channel. I remember that I could never fine-tune the receiver so that the lines were actually straight because the screen of our TV was curved. All TVs back then had curved screens because of the way that cathode ray tubes worked. There was no such thing as a flat panel display. Somehow intuitively, I knew that other people would be as frustrated about this as I was. I was sure that engineers were working on this problem. I wanted to be one of them.

Something similar was happening with the video recorder. It was an impressive machine at the time. It had an LCD screen for showing the time elapsed of a movie. It had the ability to program it with the start and end times and day of a program I wanted to record. But I vividly remember my dissatisfaction with its many shortcomings. The recording medium was a thin plastic tape inside a plastic case, with a lid that would open to expose it. The assembly was fragile, large, and expensive. The quality of the recording would degrade with use over time. The programming interface was terrible so that only someone with ample time to play with it, like a child, would ever be able to understand it and use it. I was sure that someone, somewhere was working on this problem, and I wanted to do that too.

Everywhere I looked, there was technology, albeit simple by today's standards, which made life easier, but that was clearly in need of radical improvement. Being a Star Trek fan did not make things easier. The transporter, the communicator, the talking computers, the replicator, the scanners and all the amazing things on board the Enterprise resonated with me and gave me a vision of how things can be.

A few years later, my parents bought me an Apple //e, one of the early home computers. I still have that computer. Along with it came a couple of programming books. The programming language was built-in to the computer. It was Applesoft Basic. I started programming it right away, and I felt a bit like Scotty, the Engineering Chief on the Enterprise. Now, that was technology. Now we are getting somewhere. Steve Wozniak became my new superhero, replacing Spiderman.

A few years later, I bought an electronics kit to make an LED blink with a 555 timer IC. All the documentation was basically the assembly instructions of which components go where. There was nothing about timers, LEDs, etc. I had no access to the Internet, no electronics book, and I did not know anyone who had some knowledge on these things to ask. Despite that, this is what technology was to me. Whether in a kit with all its components mixed, or perfectly assembled into a beautiful computer, I knew some engineers out there had done what needed to be done to get us closer to my Star Trek ideal.

From the video recorder to the Apple //e and then to the 555 integrated circuit, I quickly developed an intense interest in engineering and programming. But I had no access to documentation and had no-one around me to ask for help. Not only that but at school, none of my teachers was able to help me. They were all excellent in their particular subject matter, mathematics, history, geography, science, but none of them had ever touched a computer.

The fact that my school was ill-equipped to help me learn how to program my computer, or to give me some basic pointers around electronics, is simply an example of how schools do not really prepare students for the future. They prepare them for the past. I have memories of thinking how firmly I believed that computers were the present and the future, and how bored I felt at school because none of my strong interests in technology was

met. School was dreadful. I felt that I was sacrificing my best hours, every day, for a purpose that I did not understand. Perhaps school was about accumulating grades; perhaps it was about, other than for gathering marks. My boredom had affected my ability to learn, and my lack of interest made it impossible to get a grade better than average. My parents were averagely thrilled about that.

I knew I wasn't stupid. I was able to learn a lot on my own. I was lucky to have parents that had no reservations about buying books and magazines. I had an encyclopaedia, a subscription to a foreign computer magazine (I remember the difficulty of buying foreign currency to pay for it), and programming books. My software collection grew and included the Logo programming language. I found a book that taught me how to do low-level programming on the Apple //e, manipulating bytes and working with 6502's op-codes. I found perhaps one of the first science kits for a home computer, that could measure temperature and lung air capacity (I used that to train my ability to hold my breath for what seemed to my like a very long time). Home was heaven. Home was where learning was actually happening, disguised as play, at least after my school homework was done.

Today, while schools have not changed fundamentally, the sheer opportunities for learning are truly stunning. Not only there is an abundance of resources, from Arduino's to robots, to connected everything, but there is a wealth of knowledge in video, text, illustrations on your computer, your iPad, even on paper, but people with knowledge are within instant reach.

The experience of sending my own children to school reminded me much of my own school years. The fixed curricula, the separation of subjects, the focus on delivery rather than the individual, the lack of sufficient time for play and exploration. The list can go on. This recent negative experience with school was also amplified by my children's dyslexia, which made it even harder for them to develop a happy relationship with learning. Learning, under these circumstances, was externally enforced. It was painful. It was seemingly pointless. And it was distracting them from the things that were most important to them.

I decided to write this book because I was convinced that there is a better way to learn and to teach. Just like engineers succeeded in creating flat screen TVs, and improved computers and networks to the extent that we no longer need video cassette players and recorders, I was convinced that there were educators who had solved the problems that I mentioned earlier. Educators who realised that learning does not need to be painful, that children with different learning needs can be cared for. I was convinced that there are educators who can help in creating an educational system that instils its students with the qualities that we want to see in a happy and successful individual rather than the specific bits of knowledge that they need.

My conviction was not arbitrary. I had spent the last 15 years as an educator myself. First as a University lecturer, and now as an online instructor. I witnessed both the limitations of traditional education as well as the potential of Maker-style education when combined with modern educational technology. My conviction is that after the pain of the past, we are now entering a golden age of education. An age in which education is better aligned with its real purpose of helping to shape happy and creative individuals. An education that helps the learner to learn how to think critically, solve problems independently but in collaboration.

An education that helps people to think like a scientist and implement like an engineer.

Technology plays a huge role in this education. I have visited high schools where I could see the effect that technology has on the quality of learning that student can achieve. Imagine four or five teenage students gathered around a wheeled robot. They are making the final preparations ahead of a yearly robot competition. They are each working on a particular subsystem, but they all understand how the robot works as a system. There's always one student that goes deeper than everyone else. He or she does the troubleshooting, can move wires around before anyone knows what's happening, does the last code modifications for an instant performance improvement. And guess what she wants to do? Become an engineer.

I wrote this book because I had to. I needed to organise my thoughts around what a modern educational system should look like. I wrote it so that I can systematise the elements that can help my children, with their spe-

cial learning requirements, not just cope but to thrive in a world full of opportunities of any kind, but especially learning opportunities. I wrote it for my young self, struggling to keep my love for learning and curiosity alive.

I wrote it for teachers who are dedicated to creating awesome learning experiences for their students. For parents who care not just about their children's academic achievements, but also for their overall development as happy and creative individuals with their own unique set of passions and curiosities. I wrote it for the learners themselves, who are perhaps discouraged by their experiences in school and wonder if there is another way.

I sincerely hope that this book will help you change your view of what modern education should look like. Because with every successful learning, there is change.

Peter Dalmaris, May 2017

A brief history of modern education

“Education is the most powerful weapon which you can use to change the world” — Nelson Mandela

In the early 1800s, mechanised textile production spread from Great Britain to the rest of Europe and beyond. Factory cities such as Manchester and Dewsbury emerged and grew rapidly during the 19th century, with new factories attracting more and more people from the countryside.

Factories were organised in rows and columns, optimised for efficiency. At each station, a worker would repeat that same movements again and again, for the duration of his shift. At the end of the shift, a fresh worker would take his place and repeat the same movements, again and again. Just like the factory was organised for efficiency, each station was also optimised for efficiency. The repetitive movements of the worker, over time, had removed anything not strictly necessary for the task in hand. The tools that he used were built for the single purpose of the task in hand. There was almost no talking at all, since talking can increase inefficiency. What had to be accomplished can be done so with minimal interaction with other workers. Each worker was trained to do one thing; one thing only and to do it efficiently.

Thanks to the way that factories were organised, each worker only had to be proficient at a very small repertoire of functions. Assemble a box, connect a couple of wires, attach a label. The workers did not need any special training, and in most cases they didn't even need to read. In fact, these factories required workers with minimal knowledge of reading and maybe of simple arithmetic; however, most of them had no schooling of any kind, and could barely read at all.

This prompted the factory owners to create in-house training, where new workers would learn the basics of factory operation. Sometimes, this even included some reading and arithmetic.

Schools, of course, existed outside of factories. Children in the late 18th and the 19th century did receive formal education in schools that was very similar in terms of organisation to those that we are familiar with today. Although attendance was not high in the early years, it did increase to eventually guarantee that the majority of the population of a country, at least in developed countries, could graduate with adequate ability to read and write.

If you walked into a typical classroom in England of the 18th and 19th century, you would see desks and chairs organised in rows and columns. At the front of the class was a blackboard from where the teacher would address the class. The students were required to always look towards the front of the class, at the teacher. Talking was forbidden, unless the teacher had asked a question. The tools of teaching and learning were very simple, but just like their factory counterparts, they were efficient: a blackboard, chalk, books, pencils and paper.

The teacher was tasked with the responsibility of conveying knowledge to the students by means of a formal presentation. The students would be required to follow the instructions issued by the teacher, which included reading and writing tasks. The teacher would also quantify the knowledge accumulated by students by issuing formal or informal tests, and then rank the students based on the results of those tests.

Indeed, the purpose of these schools, unlike their counterparts in places like Ancient Greece and Ancient Rome, was to increase the literacy of 'common people' to a level adequate for life as a factory worker. This was the mantra of conventional, classroom-style schooling back in its early days, and, as I argue in this book, it still is.

Indeed, little has changed in the methods of schooling in our advanced 21st-century technological societies. Not only there is a striking resemblance between schooling in the 18th/19th and the 20th and even 21st centuries, but the emphasis is still in maximising efficiency and productivity (measured as the volume of product that exits the production line in a given unit of time) is the common denominator between traditional schooling and factories.

Modern factories may not be powered by coal and steam, but they typically still require workers with a basic and common level of education. Modern factories require workers, that can work harmoniously together thanks to a common set of assumptions and beliefs, optimised to deliver specific outcomes. Without doubt, comparing the level of education of the average person today to a person from the 18th century is like comparing a Tesla Model X to a Ford Model T. Yet the uniformity, rigidity and high output rate requirements of that era, to name just a few similarities, still exist in modern schooling.

Unfortunately, the citizen of a modern, technologically advanced and hyper-competitive society of the 21st century needs to be prepared to navigate a world that is far more complicated than that of our 18th-century counterpart. Globalisation, hyper-competition and frictionless commerce, rapidly advancing technologies, social change, global and localised conflicts, climate change and mass migration are only some of the high-stake issues that a modern citizen must be able to comprehend and act upon.

Even the factories, traditionally associated with low-skill work, are being transformed. Robotics, artificial intelligence and automation have evolved to a level of effectiveness enough to be rapidly replacing human labour with machine labour. This inevitable process is causing massive unemployment to people in many industries around the world. Millions of people are left out of work, with no real prospects of ever catching up in the work market. This is the generation that is losing out in this process of modernisation, and largely depend on social policies and social safety nets for ensuring the basics for their survival, if they are available.

Will the next generation of people that are growing up now be more fortunate? Will these next generations be able to adapt to a world where machines, more and more, are taking over jobs that traditionally used to be done by humans? Not just factory jobs, but jobs across the whole spectrum?

This kind of disturbance in the connective tissue of societies is not new. People went through similar experiences during the shift from the early agrarian and feudal societies to the those of the industrial revolution. Mechanisation and automation changed the ways that large populations made a living, and it did take them generations to adapt.

But this time, it is very different. The speed, breadth, and depth of changes are far bigger and more impactful than what we have ever seen in the past. The speed by which technology has moved in to redefine whole industries, combined with its global reach, means that there is no escape. People have to adapt because they can't hide from the change.

I believe that there are unique opportunities for people in a world where automation is everywhere. But to thrive in such a world, we have to exploit and believe in what is unique in humans. Imagination; creativity; drive; curiosity; empathy; self-awareness; feeling. These are some of the traits present in every human, and the raw ingredients of products like art, science, language, society, and culture.

Going forward, more than ever before, our ability to thrive in a world where machines play a more significant role than ever before, depends on our education. How we learn, teach, and magnify our uniquely human traits.

So, we have to think about school, since this is the institution with the critical task of educating the young, and preparing them for the future.

Are our schools an outdated version of the same schools that contributed immensely during the Industrial Revolution? The same schools that produced the millions of workers that powered factories and paved the way to our modern way of life?

In this book, I argue that the answer to this question is 'yes', and that a solution in modern education's dead end lies in the core of human ingenuity and creativity.

The system is broken, like an old machine. A 200-year-old machine, to be more precise. It was designed for a world that does not exist anymore. In the US, the industries that contributed the most in the Industrial Revolution—manufacturing, construction, mining and the like—comprise of less than 20% of the total output. Even in those industries, much of the demand is for people with highly developed skills in leadership, management, engineering and finance. In Australia, and other developed countries, the statistics are similar.

A modern society increasingly needs people who have a diverse range of skills. It needs people who are innovative and creative in order to generate new wealth for themselves and those around them. They need to be adaptable in order to be able to respond to rapidly and ever-changing conditions, locally and internationally. They need to be able to think independently, and to be able to set fulfilling courses for their lives.

These are people that approach a problem with the playfulness of a child and the thinking process of a scientist: people that can engineer their own solutions to problems that perhaps have never been seen before. People that thrive in complex, competitive, ever-changing and open societies.

What kind of educational system can help people become scientists, engineers, philosophers, humanists and politicians, all at the same time?

It must be a system that advocates that the individual is at the centre of the learning process. A system that believes that the scientific method and technological competency is a key component for personal and social growth and prosperity. A system that fosters collaboration and innovation, that focuses on the learner instead of the teacher, in adaptability instead of obedience, in creativity to support and enhance abstract thinking. A system that emphasises a growth mind set rather than the fixed mind set was a main characteristic of the 19th, 20th and 21st-century human.

I wrote this book because I wanted to explore this theme and show that the answer to our educational system crisis is already being enjoyed and transforming the lives of countless people around the world.

Interesting readings

- Where machines could replace humans—and where they can't (yet), txplo.re/mck
- Economy of the United States, txplo.re/eus

PART ONE

An education in crisis, and an
opportunity

Chapter 1

An education system in crisis

“Education is what remains after one has forgotten what one has learned in school.” — Albert Einstein

This book is about education. As responsible parents and guardians of children, we must ask ourselves: what is the purpose of education, and how can this purpose be best fulfilled?

This is a question that philosophers tried to answer, many centuries ago. Aristotle wrote extensively on this topic. In his book “On Education”, while only a small part survived to our days, we learn that for Aristotle, the fulfilled person is an educated person.

This leaves the question on the purpose of education somewhat open. But in answering it, perhaps we should first try to agree on what a ‘fulfilled’ and ‘educated’ person is. Then, we can explore the next logical question, which is what an education that enables a person to be fulfilled looks like.

John Locke, like Aristotle and many others, left significant works on education. In *Essay Concerning Human Understanding and Some Thoughts Concerning Education*, he argues that “education makes the man”:

“I think I may say that of all the men we meet with, nine parts of ten are what they are, good or evil, useful or not, by their education.” (1)

What are the core characteristics of a fulfilled person? Let’s flip the question and ask the opposite: What are the characteristics of a person whose life is not fulfilled? Perhaps a life full of fruitless struggles, difficulties, mediocrity and sameness, dependant consistently on externalities? A life that feels confined to the rules and wishes of others, trapped and disappointed with the system?

Contrast that to the life of a fulfilled person, who welcomes struggles and difficulties as they, more often than not, lead to personal and collective growth and progress. The fulfilled person welcome struggle because it is an opportunity for learning. Through these struggles, the fulfilled person becomes a better version of themselves.

A fulfilled person enjoys the endless vitality and diversity of life, the freedom represented by the opportunities to produce value, whether this value is material or spiritual. A fulfilled person feels safe because of their ability to adapt and respond to the unavoidable risks of being alive.

These are some of the characteristics of a fulfilled life.

Aristotle, Locke and many others discussed all this in detail, and they also suggested a method and an outline of what kind of education can help people attain fulfilled lives. They argued that an education should emphasise a holistic and balanced development, from a young age. Play is a big part of such education, and so is physical training, music, debate, and the study of science and philosophy. This kind of education develops both body and mind, equally.

And lastly, learning happens throughout life, adjusting for the different stages that a life naturally goes through.

What is the experience and outcome for most of us as graduates of formal, traditional education? Boredom. Seemingly pointless struggles. A feeling of being trapped in a system tuned to churn out graduates. In many of us, these feelings only got stronger as we grew older in this educational system. Finding a way out, towards fulfilment, become continuously more abstract and elusive.

Modern schools, with their underpinning in the Industrial Revolution, were shaped in the early 20th century after the Prussian education system of the late 18th and early 19th century. This system was designed to service nation-building at a time of significant upheaval and social restructuring. It was optimised towards teaching children blind obedience to authority, and reinforcing class and even race prejudice (2). In the US, the Prussian system was particularly influential in the mid-1800s, when it was used as the model for creating a similar system in Massachusetts. The primary driver behind the adoption of the Prussian model was the latter's emphasis on social cohesion, a very important outcome for a young nation.

The factory model in schooling, another attribute of the Prussian system, emphasises efficiency, uniformity and standardisation as paramount principles. The factory model survived almost unchanged in most of the developed world until the end of the 20th century.

The Prussian system was engineered for a specific purpose, and it was very successful at that. That is why it is still entrenched in modern national educational systems. However, the primary purpose of the Prussian system was not to help its graduates achieve fulfilment in their lives.

Today, schooling is undergoing change towards a more student-centric approach, but this change is slow, and understandably so. A system that has endured for centuries cannot be replaced within a few years or even decades. It is encouraging to see that there is recognition for the need to change and adapt to the new realities that societies face today across the spectrum of stakeholders. From students to teachers, and to the government officials and executives that make policy decisions and implement such policies. For example, in the US, the core purposes of K-12 schooling include civic, emotional and cognitive development. In the 2009 document, 'The Shape of the Australian Curriculum', policy makers pledge their commitment to "supporting all young Australians to become successful learners, confident and creative individuals, and active and informed citizens" (3).

Do these pledges materialise in the actual schooling system? In Australia, using participation in lifelong learning activities as a metric, we know that just 16% of 30-34-year-olds have participated in some form of formal learning. People in the 60-64-year-old bracket had a participation of just 3%. Participation in informal learning is much higher in all age groups. People in the 30-34-year-old bracket participated in informal learning at a very high 75.2%, and even people in the 60-64-year-old bracket participated at 64.2%.

One way to think about these numbers is that people will naturally learn what they want, outside of formal institutions. This is indicative of what the future of education may be: informal, on demand, skill-based, lifelong. As soon as people leave behind the burden of formal education, they abandon it. In Australia in particular, and this is probably true in other developed countries, people with higher incomes and higher educational qualifications are more likely to participate in both formal and informal education.

Interestingly, people who are unemployed had a participation rate in non-formal education at a very low 11%. Perhaps these people are excluded from learning opportunities because they have no workplace with the policies and systems in place to manage their personal development, or because they never gained the appreciation for it during their schooling years.

Is our educational system in crisis? The evidence seems to suggest yes. Is it changing in response? The evidence, again, seems to suggest that the answer is yes. Are people thirsty for non-conventional education? Again, the statistical evidence suggests that the answer is yes.

The change is not fast enough though. The world changes at a much faster pace than what the system is able to absorb. The good news is that, thanks to advancements in communications and educational technologies, and developments in many related fields of technology, we can all participate in high-quality and enriching, lifelong learning, starting with young children. Let's look at the good news next.

Interesting readings

1. Locke, John. *Some Thoughts Concerning Education and of the Conduct of the Understanding*. Eds. Ruth W. Grant and Nathan Tarcov. Indianapolis: Hackett Publishing Co., Inc. (1996), 10; see also Tarcov, 108.
2. *Compare Central Society of education*, Volume 3 Taylor and Walton, 1839
3. *Review of the Australian Curriculum: A statement by the Australian Curriculum, Assessment and Reporting Authority* txplo.re/rac

Maker EDUCATION Revolution

Learning in a high-tech society

Conventional education is struggling to provide the learning environment necessary to help raise the future innovators, problem solvers, and entrepreneurs that advanced societies need. While efforts to transform education in that direction are underway, they are too slow and not decisive enough, resulting in too many of our children being left behind.

In this book, Peter Dalmaris argues that it does not have to be like that. Using Maker Education as a model for education in the 21st Century, Dr Peter Dalmaris explains how teachers, parents and learners can apply the educational methods of inventors and innovators for the benefit of their students and children. With strong philosophical and scientific underpinnings, Maker Education provides a unique opportunity to complement, and even supplement, our failing conventional education. This book shows you how.



PETER DALMARIS, PHD

Peter Dalmaris is an online educator, engineer, electronics hobbyist, and father. Peter has a diverse background as an educator and learner. An academic for over 15 years and with involvement in education spanning over 30 years, Peter has witnessed a deterioration in the quality of the educational system. Peter's work as an educator includes teaching thousands of students in Universities in Australia, and tens of thousands of self-learners, from all over the world. In every case, Peter has experienced the effect that "learning by doing" has in the educational outcomes of every individual.

Are you a teacher? A parent? A learner? Then this book is for you. This book will help you to understand and apply the power of Maker Education.

Education, Society, Parenting
ISBN 978-163587122-7



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Tech Explorations Publishing