Boundaries of the Educational Imagination

Hugo, Wayne

Published by African Minds

Hugo, Wayne.  
Boundaries of the Educational Imagination.  
Project MUSE.  muse.jhu.edu/book/48268.

For additional information about this book  
https://muse.jhu.edu/book/48268
The strange thing about Johnny is that he is able to learn, in the space of twelve to fifteen years, what has taken collective humanity twenty thousand years and more to work out. We were struggling with how zero and the decimal system worked two thousand years ago, and now we get it in grade 1. Maybe the interior development of an individual learner shows up, in miniature and speeded-up form, the whole history of human development? Now that is an exciting thought. In working with one student you have the chance to recapitulate and then take further the development of our species. We don’t really know what Neanderthal men were thinking, but maybe we can find it in the earlier levels of childhood development. Johnny, sitting on that plastic chair at a trapezoid table, is actually the missing link between prehistoric humankind and us. It’s not only a beautiful world of interior depth that we find inside Johnny; it’s the whole history of us as a species.

Ontogeny recapitulates phylogeny

This was the real reason Piaget studied children. Through them he felt he had access to the genesis and sequence of knowledge development in our species. Piaget studied the concepts of space, time, causality, number and logical classes as they develop in the minds of children because they revealed in individual knowledge code the history of knowledge development. Unlike Tau, who would have to float above us for a hundred thousand years, watching us slowly and painfully mastering the massive gap between the necessities of existence and the possible ways of dealing with it, Piaget could get the same view in miniature.
and individual form by working with children. The idea is enormously seductive and has been around in different forms since the ancient Greeks. Here is Herbert Spencer, writer of one of the most popular and long-lasting educational textbooks in nineteenth-century England:

If there be an order in which the human race has mastered its various kinds of knowledge, there will arise in every child an aptitude to acquire these kinds of knowledge in the same order (Spencer, 1861, p. 5).

This idea is caught in the dismaying phrase ‘ontogeny recapitulates phylogeny’; the development of the individual shows in miniature the development of the species. The reason we go through stages of biological development as individuals (ontogeny) has to do with repeating the way our species evolved over time (phylogeny). If our species added a key new feature as it evolved, you will be able to find it in the development of an individual, especially in the earlier phases. If we assume that humans are the most developed of species (a very dangerous assumption), then it stands to reason that in our individual development from embryo to adult we shall find in compressed form evidence of all the earlier life forms in our past. Allow me to state that this is a crude and hyperbolic form: study the developmental processes of one human being and within it you will find a compressed record of the history of all life since its origin. Look at the early stages of a human embryo and you will find indicators of gills and tails from our evolutionary past as fish and monkeys.

Stephen Jay Gould provides a fascinating account of this idea in Ontogeny and Phylogeny and I don’t want to go into the details; first because he has already done it better than I ever could, but second because it gets us away from our focus on education. There are, however, two principles of the recapitulation thesis that are vital for us in understanding how it speaks to education: terminal addition and condensation.

Terminal addition simply states that a new stage of development is added onto the end of previous existing levels, much as a new floor is added to an existing building. What makes us as human beings, supposedly higher in the evolutionary sequence than other life forms, is that we have added extra stages on top. In terms of figure 5.1, we have increasingly added more stages onto ‘a’, eventually getting to ‘a’, ‘b’, ‘c’ and ‘d’. But, we have not increased our life span to make room for the extra stages, so we have to pack them in by running through the stages more quickly (or by jumping them.) We can see this in figure 5.1: stage ‘a’ becomes increasingly shorter as the number of stages increases (Gould, 1977, pp. 74–75).

This idea has been disproven biologically in this form, but it’s not so clear that it does not work in terms of knowledge evolution: is it not possible that the way we learn a subject is in much the same form as it developed over time, only we have had to condense the process? Initially all we learnt was ‘a’, but once we mastered ‘a’ we
found out about ‘b’. This resulted in having to learn ‘b’ as well as ‘a’, and then we found out about ‘c’ and ‘d’, and so on. The only problem is that we still need time to learn ‘a’ as well as ‘b’, ‘c’ and ‘d’, and we only have a limited life to do it in. At some stage we have to stop learning and get working. Spencer thought the way a subject (like mathematics) historically worked with its difficulties, overcame them and then moved on to higher, more difficult areas, which again presented complications that were overcome, is similar to the way we individually learn the subject.

Figure 5.1 Terminal addition and condensation
It is a very dangerous assumption, but one that has had a massive impact on the way we teach and learn. Strangely, the impact has partly been about lifting our foot off the accelerator in terms of learning and allowing students time to explore problem areas themselves in a creative way.

If we individually learn a subject in the same way our species worked through the process historically, then we must allow our students the same space to explore and trust that they will also find their way through to the answer, just as our species did. We might nudge them on the way by constructing the learning environment carefully, but if we are treading a well-worn path our species has already taken, we can trust the process of exploration to take the student all the way.

Much progressive education, with its emphasis on problem solving in a learner-centred environment that allows students to explore creatively an open issue with minimal guidance, can be partly tracked back to this assumption. But as more and more was added onto the end of the subject – ‘e’, ‘f’, ‘g’, ‘h’, ‘i’ and ‘j’ – the pressure built to increase the pace of learning, resulting in a modern curriculum where so much is packed into it that it is almost impossible to imagine a problem-solving student tinkering about in the classroom, experimenting with alternatives and dead ends in the slow pursuit of an answer the teacher (and the Internet) already knows.

Take a look at figure 5.2, which shows the development of mathematical concepts over the last ten thousand years (horizontal axis) and the age at which the concept is learnt in the United Kingdom (vertical axis) (Mesoudi, 2011). Notice any correlation?

![Figure 5.2 Subject ontogeny recapitulating subject phylogeny?](image-url)
Is it possible that the way we learn mathematics over twenty years (subject ontogeny) recapitulates the way mathematics has developed over ten thousand years (subject phylogeny)? Notice how more and more concepts get added on later and later, resulting in the student having to learn more and more in the twenty years allocated. But the same massive addition of concepts is happening in science, biology, history and geography. It’s a seductive idea, but as with any seduction, it is often built on untruths. This can be seen in figure 5.2 with set theory, which is a very late development in mathematics, but has been used in many programmes as one of the founding conceptual bases of mathematics learnt in primary school. So it cannot be time of discovery that gives the secret to the order in which concepts are learnt at a subject level. But that does not mean that the sequence of discovery over time does not, in obscured form, reveal the principle. Spencer did not claim that we have to follow the order of discovery of concepts in our school curriculum. For him it was subtler than that. It’s a principle that he articulated in three currently under-rated classics: First Principles (1862), Principles of Sociology (1882–1898) and On Education (1861). The person he got it from was Von Baer. And the principle is individuation.

Hierarchies and individuation

Recapitulation stated that an individual organism repeats the adult stages of previous developmental forms and then adds new developments on at the end (terminal addition) and makes time and space for these additions by compressing previous levels (condensation). Von Baer offered a different organising principle through his study of embryonic development. We start with a general and undifferentiated state that is common to all and, through a process of differentiation, become more individual and unique. Rather than go through specific early stages that replicate earlier adult levels where each state adds to the next on a hierarchical ladder, we go from a simple and homogenous state to a complex and individuated state. This means in principle that general features appear earlier than specialised features with the implication that specialised features develop out of more all-purpose features. What this means is that the only time there is a similarity between different animals is in their embryonic stage, because it is here that functions are still to be differentiated. Human beings, for example, do not go through the full history of all previous adult life forms from which the species has evolved. Rather they go through stages of individuation, starting in an undifferentiated ‘soup’ and increasingly emerge with more and more distinctiveness and particularity. We look similar to other species at early levels because we are all undifferentiated, not because we are going through a ‘fish’ stage. But as we differentiate, we take different paths. We are not different from fish because we added extra levels of development onto fish; we are different because we took a different path. Both we and fish developed, but in different ways.
The reason why I am briefly going through Von Baer’s critique of recapitulation is that it breaks a certain tendency of thought that works in a linear and hierarchical way. The recapitulation principles of terminal addition and condensation keep the same sequence of development with the only possibility of change coming from adding something to the end point. It’s the difference between the two following images in figure 5.3.

Note that with individuation the shift is from a more general undifferentiated state (starting with the circle and thick lines) to increasingly differentiated states (thin lines). The second key move Von Baer makes is to argue that there is more than one type of organisation and that each type is distinctive to the others. These types cannot be put into some kind of hierarchy as each is fundamentally different. Each type, in its own terms, shifts from undifferentiated to specialised by following its own logic, not by recapitulating the logic of previous forms. Each goes from simple to complex, but in its own distinct way. This results in a branching out logic rather than a single ladder.

It’s a key insight for an educational imagination learning how to work with different types of levels. Human beings are not the highest species because we added extra levels on top of other species. We took our own path of differentiation and individuation that has led us to where we are now. Other species are on their own paths of individuation. They have not somehow become stuck because they have not added the same level we have on top of the other levels. That is simple human arrogance. They are chasing their own lines of individuation with their own higher levels that are not ours.

It’s a view that breaks us out of assuming that maths or science should be organised in the same the way as history or geography. Each subject goes its own
way, with its own set of differentiations that make it unique. That is why each subject produces experts who are different and who act, think and feel differently about the world because each subject goes off on its own individuating path. To expect every subject to reach a higher level that looks exactly how the higher levels of mathematics and science looks is dangerous. Von Baer’s concept of individuation through differentiation has a lot to offer us in education and one of the people who saw this most clearly was Spencer.

**Spencer: from simple to complex**

Spencer was as famous in the late nineteenth century as Michel Foucault was in the late twentieth. Foucault gave us ‘power’ as a general organising principle through which to see the world. Derrida gave us ‘deconstruction’, Sartre ‘existentialism’ and John Dewey ‘pragmatism’. Sadly, we have mostly forgotten Spencer, who gave us evolution and progress as the guiding principle of all reality, whether it was physics, biology, psychology or education. As with Foucault’s power, if you understood the first principles of Spencer’s system then the whole world unlocked for you. The principle was that all reality, not just life forms, moved from the simple and undifferentiated to the distinct and complex, but with different subjects taking different paths.

Now, we propose in the first place to show that this law of organic progress is the law of all progress. Whether it be in the development of the Earth, in the development of Life upon its surface, the development of Society, of Government, of Manufactures, of Commerce, of Language, Literature, Science, Art, this same evolution of the simple into the complex, through a process of continuous differentiation, holds throughout. From the earliest traceable cosmical changes down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous is that in which Progress essentially consists (Spencer, 1857, pp. 446−447).

Simple homogenous things come together as an aggregate and this meeting causes differentiation of the various elements into components that are integrated into a more complex and coherent heterogeneous whole. These complex wholes can also compound, causing higher levels of differentiation and integration, resulting in continuing levels of development and progress that show increased adaptive functional capacity. A single simple element can perform only a highly limited range of actions, while a complex differentiated whole can respond in different but co-ordinated ways to the complexity of the environment by developing internal complexity. Differences are connected in highly organised ways, resulting in specialisation of functions. This in turn produces interdependence as each specialised function has to rely on others to do their bit. If the integration is
not held in the face of environmental and internal pressures, then the complex whole can disintegrate. There is no inevitability to integration: times will arise when disintegrating pressures overwhelm the attempt to integrate and collapse becomes possible. These principles are applicable to all aspects of reality.

Spencer argued that the education of the child should go ‘through a process like that which the mind of humanity at large has gone through. The truths of number, of form, of relationship in position, were all originally drawn from objects; and to present these truths to the child in the concrete is to let him learn them as the race learned them’ (Spencer, 1861).

It seems, at a superficial level, Spencer is saying that if the ‘race’ learnt maths from basic arithmetic, through algebra and geometry to measure theory, then so should the child. But he is not saying that. He is pointing to a progression that works, not in terms of the sequence of historical concepts but of the shift from the simple to the complex, from the concrete to the abstract, and from the empirical to the rational (Spencer, 1861, p. 153). These all work with climbing levels, which is the major focus of this book, and, like Piaget, Spencer is a master of the climbing device in ways that speak directly to education.

It’s at this deeper level that the way our species engaged with knowledge plays out in the individual child, not only or mainly in the sequence of topics. For Spencer the question of what should be in a school curriculum does not only revolve around mimicking the social and cultural history of humanity. He puts this into six education principles and I follow him closely in the list that follows:

1. Education should proceed from the simple to the complex, or from the homogenous to the heterogeneous, from the single to the combined and this should happen inside subjects and also in the ensemble of subjects, starting with a few simple and general subjects at the beginning and moving on to more subjects of increasing complexity later.

2. Lessons should go from the concrete to the abstract. It is important to distinguish the difference between simple/complex on the one hand, and concrete/abstract on the other. When a generalisation is made from many concrete particulars, it simplifies the many elements into one whole. Does this mean that because a generalisation is a simplification it should come first? Spencer pointed out that only ‘after many single truths have been acquired does the generalization ease the memory and help the reason’ (Spencer, 1861, p. 121). There are two processes at play here. First, a move from simple particulars to a more complex whole; and second, the complex whole finding an ordering relation between the various particulars. It is this abstract ordering that creates a simplification effect, not for each simple particular but for the complex whole.

3. With these two principles in place, he puts forward the recapitulation thesis for education: ‘As the mind of humanity placed in the midst of phenomena
and striving to comprehend them, has, after endless comparisons, speculations, experiments, and theories, reached its present knowledge of each subject by a specific route; it may rationally be inferred that the relationship between mind and phenomena is such as to prevent this knowledge from being reached by any other route; and that as each child’s mind stands in this same relationship to phenomena, they can be accessible to it only through the same route. Hence in deciding upon the right method of education, an enquiry into the method of civilization will help’ (Spencer, 1861, pp. 123–124). Notice Spencer says method of civilisation, not order of topics in some sort of magical series. So what is the method of civilisation for Spencer? He gives an indication in the fourth principle.

4. A leading fact in human progress is that every science evolved out of its corresponding art. It results from the necessity we are under, both individually and as a race, of reaching the abstract by way of the concrete, that there must be practice and an accruing experience with its empirical generalisations before there can be science. Science is organised knowledge and before knowledge can be organised some of it must first be possessed (Spencer, 1861, p. 124). Every study should have a purely experimental introduction and only after an ample fund of observations has been accumulated should reasoning begin. Hence, the fourth principle: every branch of instruction should proceed from the empirical to the rational. If a curriculum is set up according to these first four principles, then a child should trace the way humankind reached knowledge by repeating the process of discovery, not by being told the content.

5. In doing this, pleasurable excitement will be encouraged in students, rather than the boredom forced by rote learning.

From theory to practice: examples of how not to do it

It is sadly the case, however, that educators under the influence of evolution at the end of the nineteenth century tended to go for a more literal version of recapitulation in which the school curriculum was ordered in the same sequence as the history of Western humanity. Gould gives a particularly humorous account of the results in Germany and the USA. Ziller and Rein, the only two professors of pedagogy in Germany in the 1880s, developed a primary school curriculum based on cultural epochs. Ziller provided the principles and inspiration, Rein the hard graft of converting the dream into eight volumes of actual curriculum. The principle was that

[...]he mental development of the child corresponds in general to the chief phases in the development of his people or of mankind. The mind development of the child, therefore, cannot be better furthered than when he receives his
mental nourishment from the general development of culture as it is laid down in literature and history. Every pupil should, accordingly, pass successively through each of the chief epochs of the general mental development of mankind suitable to his stage of development (Gould, 1977, p. 150).

Gould notes that this worked fairly well for history, literature and moral education, but not so effectively for science, biology and mathematics. Were you supposed to teach the four humours and alchemy before modern biology and chemistry, that the Earth was flat before teaching it is round, that the sun moved round the Earth before reversing it, or that the number system should work with a base of 60 (the Babylonian numeral system) before moving on to a base 10 system? Ziller did recognise the difficulty and recommended that modern science and mathematics be taught logically, but that its examples should be drawn from the cultural epoch the child is currently studying. As Gould sardonically noted, this meant the teaching of geology and meteorology while hearing tales of Noah and the flood (Gould, 1977, p. 151) and considering mammals while the animals walked in two by two (could not help my own absurd addition). American applications of recapitulation used similar solutions and taught maths and science using examples from the historical and literary epoch organising the year. For example, McMurray from the University of Illinois designed the following curriculum in the late nineteenth century. First graders had, as a literary and cultural focus point, Anderson’s The Fir Tree. Science looked at white pine trees, numeracy involved counting the number of pine needles and music used ‘High in the Top of the Old Pine Tree’. Gould’s delight in recounting this absurdity mounts as he goes on to describe how third graders, absorbed in Robinson Crusoe, would be drawing a stalk of wheat, counting the number of grains in a head of wheat and cheerfully singing ‘When the Corn Begins to Sprout’ (Gould, 1977, p. 152). Why Robinson Crusoe? Because the text catches our initial existence as savages, and what could be better for little savages than to imagine what it’s like to be a savage. Johnny, sitting at his increasingly defaced table, could do with some savagery education.

This failure of the educational imagination is funny, but no funnier I suspect than what we are currently doing with multiple intelligence theory or neuro-linguistic programming. But what recapitulation did do, even though it died an explicit death as a biological theory, was provide strong support for the progressivist ideal of child-centred education in two related ways. First, it encouraged an integrated curriculum based on themes or issues; and second, it encouraged a learner-centred approach where the teacher did not have to do anything more than facilitate the process of discovery. Why? Because the child was in any case going to go automatically through the stages of development, best do it in a natural way just as nature and culture intended. Start off with exploration and open questions and allow the child to make the same moves that we did as a human species. Through mistakes the child will learn as we all did. Best of all, because as a species we have
done it countless times before, it will somehow be easier. And it is here that Gould’s own ideological preference for progressivism comes through in his highly qualified comment that ‘much of the little that is good about modern American education follows an ideal that triumphed with the strong aid of recapitulation’ (Gould, 1977, p. 155). That progressivism partly triumphed due to false premises should give us cause for concern and make us question its supposed success as Kieran Egan (2002) points out. He indicates all that is wrong in Spencer, Dewey and Piaget and is a useful corrective to the more descriptive account given in this book.²⁵

But we don’t have to read his book, just go back to our previous chapter and cognitive load theory. A novice child at the beginning of a task should not be given an open problem to tinker with, eventually solving it through trial and error, because this will result in cognitive overload. We need to build in strong supports and scaffolding at the beginning to reduce extraneous cognitive load and allow enough space for germane cognitive load. Make no mistake, we want a child to reach a level where she is in control of her own learning and actively solving difficult problems, but that’s not how you start out. An expert, as Spencer undoubtedly was, would love an open problem to solve, but that is not how a beginner works and we all are beginners again and again in our lives. The danger with allowing an open explorative space for beginners does not only revolve around cognitive overload, but also with time wasting, given the amount we increasingly have to learn in a limited time. Just because our ancestors started in an exploratory mode does not mean that we have to, or should. This is a fallacy. Cognitive load theory clearly points to the need to start off simply and slowly shift to more complex developments; but it certainly does not recommend starting off in the dark when we can provide clear, worked, simple, telling examples that get the learner on the right track. Spencer, it must be said, has a lot for which to answer.

Will the increase in knowledge ever stop and how will education keep up?

What the principle of recapitulation does foreshadow is the issue of the growing amount and complexity of knowledge our modern world is adding cumulatively. This is a version of terminal addition we mentioned earlier, where we have to add more and more on top of an ever-growing pile. The difficulty education has with this growth is compressing all of this information into a manageable set the next generation can master to continue the growth. This is a version of condensation, also mentioned earlier, where more and more has to be compressed into less and less. It is not so much a matter of the individual learner recapitulating what has gone before at the level of humankind, but of the exponential growth in knowledge and what education can do about it. Initially, parental and communal forms of education were sufficient to transfer the knowledge and skill pool from one generation to another, but with the age of enlightenment and industrialisation came the increased production of knowledge, resulting in a gap forming between
what communal and folk forms of education could do and the increasing pool of specialised knowledge needed in a modernising world.

Formal schooling arose partly to meet this gap, but this has only resulted in more specialisation and increased knowledge production. Does there not come a time when schools just cannot cope with the amount of new knowledge required to be mastered? And can the same not be said for our children? Will it eventually become impossible for them to learn all that is expected of them? Are we not already finding that we have to cram more and more stuff into our curricula just to keep pace with all the new additions? Many high schools now teach calculus, a mathematics topic that used to be the preserve of universities, and similar pressures are on science, biology, geography, and accounting. This results in compressing more and more stuff earlier and earlier until something has to give. If scientific knowledge is increasing all the time, then surely this flood must spill over into the school curriculum? The seriousness of this pressure becomes more intense when we realise that scientific knowledge is not just growing, it’s growing exponentially (figure 5.4). Rather than simple linear growth that adds new elements, the growth is doubling and then doubling again.

Figure 5.4 Linear and exponential growth
A good example of this can be seen in the number of mathematics publications that doubles every fifteen years or so. Eventually is there not going to come a point when, like Scotty on Star Trek, we exclaim ‘We cannae make it go ‘ny faster!’

Alex Mesoudi (2011) thinks we shall reach such a saturation point where the exponential accumulation of knowledge has to slow down. Rather than an exponential curve upwards (A) we shall hit a set of real world constraints that will flatten the curve (B).

He points out that the cost of learning the previous generation’s accumulated knowledge continually increases as both the amount and complexity of that knowledge grows. It’s taking longer and longer to learn.

Mesoudi uses a paper by Jones (2010) to drive the point home. Jones took a look at the mean age at which Nobel Prize winners made their breakthrough discoveries and found it was going up. The same trend was found with significant inventors. In 1900 the breakthroughs tended to happen at around the age of 32; by 2000 it had gone up to 38. A longer period of training and mastery is needed. If we put a scientist as a baby in the middle of a circle that represents all s/he needs to master in order to get to the point where a new breakthrough is possible, represented by reaching the circumference of a circle, then in 1900 the scientist had less distance to travel than in 2000 (figure 5.5).

Even though it’s taking longer for scientists to reach mastery levels that enable breakthrough, there is no corresponding increase in productivity over the age of 40. We still age in the same way. The reason why there is more knowledge being continually added has to do with the growing population of scientists, not that individual scientists are producing more in old age (with exceptions, of course.)

---

Figure 5.5 Expansion of invention breakthrough point
In 2000 scientists are taking longer to get to the point where breakthroughs are made, but still showing the same drop off in productivity after hitting 40, probably due to assorted family commitments and mid-life crises (figure 5.6).

Scientists have responded in part to this dilemma by intensifying the focus of their specialisation, thus reducing the amount of content and time needed before breakthrough becomes possible. But this results in such narrowing that it becomes difficult to see the bigger picture and get a sense of the possible applications of the research, and a drop in innovation potential. Another trick used by scientists is to take drugs that concentrate the mind, the only problem being that this enables intense focus on details whilst disenabling emergence of the big picture.

In chapter 3 we explored how to increase the capacity of our working memories, even though it stays limited to around four slots, by chunking, long-term memory networks and automaticity. Is it possible to do the same at the level of our species when we are faced with a tidal wave of knowledge threatening our future ability to innovate? Can we improve the way we educate to the point where we keep abreast of the increasing amount and complexity of knowledge? Can we condense and compact what needs to be learnt while at the same time working out the most effective ways to teach what is most important in the first thirty years of an individual’s educational history? Or should we search for another way of living life on this planet and doing this thing called education? The worrying aspect about the above discussion is that improvements in education will probably only delay saturation point, not get rid of it. Maybe some kind of levelling off is what is needed. If \[ Z \] in figure 5.7 simply represents the amount of knowledge and \[ t \] the amount of time used for education, and assuming we can go from our current efficiencies in education (B) to a more supercharged education (C), are
we not simply delaying the inevitable at massive cost to our children who will start education at three and graduate at thirty, working all day and studying every night simply to get to a point where something interesting can be said? Japanese children are already feeling the pressure. Their evenings, weekends and holidays are all sacrificed in the struggle to master the ever-growing pile of knowledge. Is there a limit, where no matter how efficient education is, and no matter how hard students learn, there comes a point where we just cannot learn any more in a lifetime, where the upward curve of learning new knowledge has to flatten out, as indicated by the supercharged education line below? Or given our ability to chunk information into bigger and more cohesive systems, and our ability to condense more and more information into tighter and tighter networks, can we not keep moving learning upwards and outwards?

![Figure 5.7 From folk education to supercharged education](image)

So what are the educational moves being made at species level to improve the amount and complexity of what we learn and how we learn it? Well, first we are spending more and more time learning. And this is not only in the Far East. My friends’ daughter, who is currently (2015) ten years old, finishes her day on average at six at night, sometimes later, because of all the things she has to learn and practise. And then she still has to do homework.

One way to escape this massive expansion in the time needed for learning is to make a grand plan of what is needed to be learned and then stick to it, day by day. Take the fundamental and intermediate levels of all the organised knowledge of
humanity and make maps of it that go from simple to complex in various subjects, as Spencer suggested. Then organise lessons or modules for each element as well as the links you need either to go forward into more complexity, backwards to simpler elements, or across into similar and related areas. Again, this is much as Spencer envisioned in his account of the progression of science. Start with basic elements, simple links and clear levels that build up into higher and higher levels. Spencer suggests that these will tend to be subjects that have worked out how to quantify their focus area in systematic and formalised ways. Make sure that every module provides enough opportunity for practice and experimentation (Spencer’s fourth principle, but make sure that this is done in ways that work carefully with cognitive load by scaffolding the process), with assessments that check whether the student has grasped the main point, and ensure the particulars build towards a greater whole.

Once the student has successfully completed a module, open out possible future modules based on past performance, type of interest, similar themes and, most important, use modules that are one level of complexity higher. Make this map of knowledge and all its lessons freely available for anyone to use at any time in any way they want, but order it so that there is a logical progression (Spencer’s fifth principle). Expect that, given this room to work in your own time and pace with discoveries set to build up cumulatively, there will be an explosion of energy and excitement that motivate and drive students (Spencer’s sixth principle); and that by navigating their own path they will trace the fundamentals of our current knowledge base. Every person in the world will have access to all knowledge in a structured and principled form and be able to chart a path through it that leads from simple to complex, from concrete to abstract, from the empirical to the rational, across different subjects, each subject moving off from a simple and basic starting point and going in individuated directions that often resonate and integrate at higher levels with each other. And what’s more, if you really like the idea, then go onto the Internet now and take a look at how this route is currently being chased, in a very early and still developing form, by Salman Khan.

From one class schoolroom to one world classroom

Salman Khan was a hedge fund analyst settling in to his million dollar a year salary. In 2004 he posted some maths lessons on YouTube for his cousins. As he sardonically notes in his excellent Technology, Entertainment, Design (TED) talk, they preferred the Internet version because they could pause and repeat him at their leisure. They could use a very public medium for their own personalised learning. What Khan did not expect was the uptake from various other YouTubers who could do the same thing. Excited comments started to accumulate from people suddenly understanding concepts they had not been able to grasp before, and doing it in their own space and time at their own pace. For Khan, the hedge
fund analyst, this was a good feeling; to be doing something of social rather than monetary value. And what was more, each of the lessons he posted on YouTube stayed there to be used by as many people who had access to the Internet. Unlike other people who posted lessons on the Internet, Khan kept going. He currently (2015) has over five thousand videos of himself teaching individual modules that have been delivered from YouTube over 500 million times. This kind of response has generated enormous interest and funding, enabling Khan to take the videos way beyond a set of extra lessons for his cousins. It’s taken him to a point where he can start to taste what it would mean to have a global, one world classroom offering high quality education for anyone at any time; a free virtual school for the world (Khan, 2012). At the beginning of 2015 he has 15 million students in 190 countries. Obviously there are massive fall out rates and YouTube views that don’t last for longer than a couple of seconds, but this does not counter the fact that millions of students are learning maths, science, biology, computer programming, and many other subjects through this world portal to education.

Khan has the beginnings of a foundational map of the formalised knowledge of humanity. It’s at a very early stage, but its working principles have already emerged. It works from simple to complex; and from a generic skill set, it differentiates into individuated subjects that use the same base but go in different directions. Each module comes with an extensive set of exercises (that provide immediate feedback) and once you get the ten questions right, you move on to more advanced modules. You go from pre-algebra to early algebra to algebra to pre-calculus, and also have the choice to move into different fields of knowledge like logic, computer programming, grammar and genetics. Most of these fields are quantifiable and have explicit combinatorial rules that build on each other, allowing for a hierarchical organisation that shifts into an increasingly networked set of links as you reach higher levels, which often demand a number of lower-level modules from different areas.

To encourage interest and continued participation Khan has used numerous strategies. Immediate and continuous feedback is generated through an enormous bank of tests that provide the student with guidance and correction. Encouragement is given through a system of rewards and ‘games’ (badges, avatars, points, missions) that provide extra impetus and energy. Even an old gnarly professor like me gets happy when he gets a badge after doing a particularly hard section on fractions.

Schoolteachers have picked up these video lessons. Initially just the videos were shown in class, but with the design of practice exercises a whole new world opened out. Imagine a device that tracked what every single learner was doing in the lesson, plus all previous lessons, using the videos and responses recorded on a tablet. A teacher could see where every learner was, where they were doing well and where they were struggling, what their choices and patterns of learning were, and how fast or slowly they were moving through sections. Rather than giving
a one-size-fits-all lesson, the teacher is freed to move around the class helping individual learners, armed with data that shows where excellence and problems lie. Imagine all this data going into massive data banks to be analysed for possible improvements and eliminations of inefficiencies.

Homework can become a very different phenomenon with this kind of pedagogy. You go home to do the actual lessons in your own time and come to school to discuss them and check on your questions, misunderstandings, confusions and suggestions. The classroom flips, with school done at home and revision at school. Khan calls this the flipped classroom.

Some anecdotal evidence is emerging from tracking students. There are often sections that individual learners take a long time to master and then there is a burst of speed where a number of modules are quickly completed before another module is hit that takes longer. These vary per individual, but it does not matter as each individual can work at their own pace.

More than this, the teacher could keep track of the class as a whole. Khan has developed a dashboard system that keeps track of the whole class, with both individual trajectories and overall performance updated in real time as the students go through the course. The dashboard does not only work in classrooms. Parents could use it for individual children; districts for the relative performance of schools; countries to keep track of all their students; and the world to account for its own learning. Tau, floating above us, could keep track of how we are doing relative to other intelligent life forms.

This is a little too much to ask of one person who has currently (2015) recorded almost 5000 YouTube videos, even if he intends to continue posting videos for the rest of his life (which he does.) It’s also too much for video technology, which on its own cannot replace all the other forms of education out there, or all the ways pedagogic interactions happen. Sal Khan does not make this claim and indeed he hopes that the videos will, if anything, free up teacher time precisely to pursue more complex and dynamic pedagogic practices. But what Khan is coming to appreciate, as the millions of hits on his videos grow, is that there are teachers out there who have done what he has done in ways that are better than his own intuitive approach, struggled with ways of improving comprehension of a concept by interrogating the minutiae, and developed ways of teaching that result in deep understanding and mastery rather than a superficial sense of having grasped a concept by answering ten questions. This has even forced Khan to remove videos that contain mistakes, meanderings or badly put sections. What he is doing intuitively has often been done by others in more pedagogically rewarding modes, with better structuring of earlier learning, more profound assessments and more rigorous pushing forward to higher levels of complexity or more intense levels of application. Sal, as he likes to be called, currently (2015) has a team of eighty people. As the Khan website proudly puts it:
What started as one man tutoring his cousin has grown into an 80-person organization. We’re a diverse team that has come together to work on an audacious mission: to provide a free world-class education for anyone, anywhere. We are developers, teachers, designers, strategists, scientists, and content specialists who passionately believe in inspiring the world to learn.

What he has done is enable us to glimpse what it would mean to have a one-world classroom that will open out for all of us the ever-growing knowledge of humanity in ways that take us beyond formal schooling as we currently experience it.