Chapter 6

From one-world classroom to one learning sequence

Making all the knowledge of the world pedagogically available in an organised and accessible form for everyone, anywhere, any time is a twenty-first century project, but this vision is built on the success of each elementary learning sequence and how they combine. And it is in these details that the devil lies. Khan cannot do it on his own, no matter how many lessons he posts and organises on his knowledge map; that is why he has eighty highly qualified, dynamic workers helping out. But as astonishing as Khan Academy is, we already have hundreds of thousands of good textbooks and thousands of curriculum plans mapping out both the content and sequences of hundreds of subjects across hundreds of countries, never mind the individualised lesson scripts of millions of teachers going out to billions of students continuously as the world quietly rotates on its axis. What strategies are possible on a micro level and can these micro-elements somehow organise and cohere into a supercharged education environment that pushes beyond our rapidly aging formalised schooling model? So just as we shifted from the macro picture of all the schools of the world to a micro focus on desks, chairs, and writing equipment; we now shift from the macro perspective of all the world’s knowledge to a micro focus on learning sequences. Four recent developments give us clues to the shape of the new terrain of education: ontology-based learning path generation schemes, learning hierarchies, lesson objects and free access learning.

The problem with Khan’s virtual school of the world is that his video lessons cannot change and adapt to the specific requirements of the student. The lessons can reach any student who has access to the Internet and the determination to self-directed learning. The student can stop and start, rewind and go forward at
hir own pace, but the lesson itself cannot change its starting point, sequence and end point. Khan would have to redo the video lesson, which he does, but he still has thousands of future lessons to do, making looking backwards very difficult indeed. With many of his lessons he has already done them twice after working out misunderstandings; but a third rework and a fourth?

If you step out of Khan’s self-contained virtual classroom into the chaotic environment of available lessons online, which lessons are better than others and how do they combine? You can find whatever you want, but it’s in conditions of cognitive overload and wastage. Individual teachers can organise this chaos and adapt sequences for their own students, but they are tied to one place, one time and one batch of students. Is it possible to develop an automatic learning sequence that starts where an individual learner needs it to start, moves in a sequence that adapts to the responses of the student, and from performance assessment develops better learning sequences and so on in a virtuous circle of continuous pedagogic improvement? Let’s get clear what possibility this question is pointing to – a system that automatically improves its ability to respond to individuals based on their particular demands and abilities. Any student, at any level, can start at any point, and the computer program will work out where the student is and what to do next that is in tune with the student. At a micro level you would need the following ingredients: a learning task that involves a number of steps; a possible set of sequences through the learning task ordered in different ways; a pre-test that identifies prior knowledge; a post-test that evaluates the results and effectiveness of the learning sequence; and a way of re-ordering or changing the sequences based on student responses to the pre-test, during the sequence and afterwards so as to develop optimal learning pathways. If this worked, then a virtual school of the world could have inbuilt evolutionary mechanisms for the improvement of each of its lessons. The more the lessons were used, the better they would get because the mechanism would work out the best sequences of learning for individual students based on personal past history and the responses of all other students. You would go online, do a pre-test, from which the programme will work out what level you start on, and then based on your responses as you go through the lesson, it would change and adapt the lesson steps to suit your own peculiar demands, strengths and deficiencies, based on the results of thousands of responses and effects before you. Artificial intelligence combined with mass use becomes a pedagogic tool to improve our individual intelligence radically.

Pedagogic engineering

Chih-Ming Chen (2009) provides a glimpse of how this is possible using ontology-based concept maps to develop personalised learning paths. (I can’t help but perversely chuckle as I write this: after dutifully going through ontogeny recapitulating phylogeny you get thrown into ontology-based concept maps.)
Ontology in information science and artificial intelligence technologies is something different from its meaning in philosophy (Smart, 2003), but there is a general overlap where both are concerned with what exists and how to sort it into different categories. Both work with kinds of objects and processes, how they are structured and how they relate. Ontology refers to what the object is and what its elements are. Within the computer-based learning community, ontology refers to a defined vocabulary of all the relevant terms in a subject area as well as their logical relations and combinations.

Ontology dreams of providing a complete classification of everything that exists and provides the fraught beginnings of a technical armoury needed to tackle the question of how to organise pedagogically all the knowledge of the world. I say fraught because both in the information sciences and philosophy, the task of developing a classification of the world has turned out to be massively complex and contested. Classification schemes conflict and hive off in different directions, depending on focus and purpose. Using a concept from the previous chapter we could say they individuate in different directions, making a general ontology of all subjects an almost impossible task or one that is doomed to stay at such a generic level it says nothing of value to individuated disciplines. Another problem is that certain types of knowledge are better suited to a strictly defined vocabulary and a small set of logical relations. It doesn't work that well on Shakespeare, for example. Furthermore, pedagogic undertakings involve far more than working out a classification scheme. It is necessary to select from the classification what is needed in real time in a specific context, elaborate on it, sequence it, and evaluate it in its transformed state. But that does not mean ontology should be relegated to the background in the twenty-first century project to make all knowledge available to anyone at any time in any place in pedagogically enlightening ways that automatically configure to individual profiles. It means that ontology sits as a troubled necessity of our modern educational project.

If ontology is about how to carve the world up at its joints, what is an ontology-based concept map? It’s an attempt to take a specific domain of knowledge and provide clear definitions of the basic concepts and processes attached to it, as well as how they combine and interact. Let’s take a simple, well-defined domain like ‘fractions’ as a starting point. Two immediate problems jump out: what are the basic concepts and operations needed to understand how fractions work; and how do they relate to each other? Even if you were able to gain some clarity on the elements, the problem is that some are more basic than others and some need other elements as building blocks. Let’s say you identified seventeen different elementary units needed to understand fractions by consulting expert teachers and textbooks. You would still need to work out the order in which they should be placed. This would not be arbitrary. You could not do them in any random order: some sequences would be better than others; but which ones and for whom? If you asked expert teachers or consulted textbooks you would find that even...
after reaching agreement on the basic units, there would be different sequential orderings. At this point Chen does something very interesting. He administers a fraction test based on the seventeen units to six hundred elementary learners and then ranks the units according to difficulty based on wrong answers (the more learners get the unit wrong, the harder it is.) This gave him a ranking order from 1 to 17 based on the difficulty level of the course material (Chen, 2009, p. 1035), with 1 being easiest and 17 hardest.

1 – Equal parts
2 – Division as sharing
3 – Division as separating
4 – Sharing with a remainder
5 – Separating with a remainder
6 – Parts of a whole
7 – Improper fractions
8 – Sequence of fractions
9 – Comparing proper fractions with the same denominator
10 – Comparing proper fractions with different denominators
11 – Adding and subtracting fractions
12 – Adding fractions
13 – Subtracting fractions
14 – Missing addend
15 – Missing subtrahend
16 – Missing summand
17 – Missing minuend

Using this as a sequencing base, he compared it to the way four Taiwanese textbooks ordered the seventeen components and what he found is fascinating, if unsurprising. Each of the textbooks orders the seventeen units into different sequences. The teaching order did not necessarily follow the difficulty order (Chen, 2009, p. 1046).

What you could do at this point is just average out the teaching orders of the four textbooks and work with the most common combinations as your integrated teaching sequence, but this is dangerous as there are reasons behind each textbook sequence that put them on different paths. If at an early point in the sequence you choose to go with one option rather than another, this powerfully impacts on how the rest of the sequence unfolds. Averaging it out could create a mush in which different functioning paths are melted into one fuzzy mess. Even more complicating, all the textbooks put some fairly easy components near the end, because, even though they were easy, they were only needed once the basic steps of working with fractions had been worked on. Number 7, for example (improper fractions), is only of middling difficulty but it comes near the end of all the textbook sequences. This helps provide some clues to ordering the sequence of units that
goes beyond just using level of difficulty. What matters is the *internal logic of the sequence*, not only moving from simple to difficult. A further complication arises from how different learners perform in the pre-test. They make different kinds of mistakes in different units and the units they can and cannot do are different from other learners. It’s not as simple as designing a sequence that works from one to seventeen and placing learners somewhere on the sequence. It’s about working out what kinds of combination to offer individual learners based on their previous knowledge base. Each learner will show a different profile depicting what they can and cannot do and the difficulty is working out which sequence to offer them in response to their profile. Expert teachers can do this, and that is why they are so valuable; but can a computer programme?

Chen tries to show how it is possible by quantifying the relationships between the conceptual units. Unlike an expert teacher, who qualitatively understands how fractions work as a whole and the different paths through the whole course, a computer can only work with quantification and decision trees based on it. If the quantification process works, then rather than have an expert teacher always on hand to decide which way to go with different learners, the learning sequence becomes automated but still provides individual learning paths that work. Chen attempts to do this by taking the test records of the six hundred elementary school students who did the fraction test and looks for correlation frequencies between the incorrect and correct answers. He puts them into a concept correlation table in which the higher the number the stronger the correlation. It allows him to work out which concepts are related to which based on what learners can and cannot do. It basically quantifies the following logic: if the learner can do this and this, then they also tend to be able to do that and that; if the learner cannot do this and this, then they tend not to be able to do that and that; and just because learners can do this unit does not mean they can do that unit, and so on. It starts to match the same qualitative process of an expert teacher, but does it blindly according to numbers (Chen, 2009, p. 1038).

You don’t get sequences from a correlation table, but clusters where different concept units hang together with high frequencies. Chen finds ten clusters. Forgive me for not getting into the precise mechanics of how he does this as there is a more general point I want to illustrate. The point is that he is able to combine the levels of difficulty of the seventeen units with a conceptual ordering into ten clusters and it is this combination that gives him an ontology-based concept map (Chen, 2009, p. 1040) that works with both increasing difficulty and how the different components of fractions hang together in clusters. Get something wrong in one cluster and the computer knows what other elements you probably don’t understand, and can take you there automatically.

One final point on this strange new world of pedagogic engineering. The textbook analysis of all the different sequences revealed that number 10 (comparing fractions with different denominators) always came right at the
end. This component was not the most difficult at all, but it does contain within its operations the basic elements of all the other components. All the clusters correlate highly with component 10. Component 10 might not be the hardest element, but it’s the one that all the others refer to and in all the textbook sequences it comes right at the end because it contains elements of all the others.

It’s still very early days for this kind of intricate pedagogic engineering, but it is certainly not the last we shall hear of this kind of work. Big education companies like Pearson are charging ahead with these kinds of programming technologies because they offer cheap and automated alternatives to expensive teachers but still offer individualised feedback. Eventually this sort of programming starts to feed off its own base. It keeps track of learner performance before, during and after the module has been worked through. It can blindly work out which sequences work for what kind of student profile and continuously improve the way it does this by checking the success of the sequence selection in the post-test. Over time the best sequences for all sorts of learner profiles will emerge, making it a formidable competitor to the expert teacher. Imagine a virtual classroom of the world that takes you from where you are and plots a learning course especially for you based on what thousands of other students have found works, or does not work, for them; all done automatically. For capitalists in education it offers massive profits at minimal cost.

I have a complex reaction to this kind of pedagogic engineering. On the one hand it sets up a solution to the problem of cognitive overload and wasted time that comes with the explosion of information on the Web and the proliferation of e-learning sites. Learners become disoriented by the choices available and disheartened by dead end paths that don’t link up into a more systematic and coherent whole or by going through a predetermined sequence that does not fit their own knowledge profile. Automated conceptual ontology maps offer a vision of a world classroom that uniquely adapts itself to each learner and continually improves how it does this as more and more students use it. On the other hand, it sets up the conceptual sequences based on external and quantitative drivers such as levels of difficulty and the clustering of mistaken answers to tests, not on the actual internal logic of the subject. Out of the ordering of fractions in the four Taiwanese textbooks, is there not a way to decide which are optimal, based on how fractions work? What about locking the four writers of the textbooks up in a room and telling them they can only come out once they have agreed on the best sequences? Note I am not saying one best sequence, that is a simple-minded dream we have to throw away. There will always be a number of paths to the same end point, but we should not forget that a good teacher uses the internal logic of the subject, not external quantifications, to work them out. But with quantification comes the possibility of breaking away from dependence on one teacher at one time in one place, and reaching for a world that can adapt to any student at any time in any place. The specialised work of teaching is in the process
of becoming an algorithm. Just as pharmacists are being replaced with diagnostic software that asks you ten questions and then prescribes your medicine, so too are teachers being replaced with pedagogic software that asks you ten questions and then prescribes a learning sequence.

**Learning hierarchies and cumulative learning**

Structuring a learning sequence qualitatively, based on the internal logic of a specific topic, concept or capability, has a long and venerable history in instructional design. One of the earliest and clearest articulations of how to do it comes from Gagné’s work (1962) on learning hierarchies (Richey, 2000). At the heart of the process lies the asking of the same question over and over again of a specific task or topic, each time at a lower and more specific level: ‘What would the individual already have to know how to do in order to learn this new capability simply by being given verbal instructions?’ (Richey, 2000, p. 68).

Notice that this question does not deal specifically with the content of the topic, but with the subordinate skills. It’s a hierarchy of capabilities, not of concepts. Notice as well that the question has a peculiar edge to it: what sub-components must a student know in order suddenly, at a certain point, to find that she can handle the new capability simply by being asked to do it. It is kind of what happens with the fraction example above, C10: compare proper fractions with different denominators. When asking this question on the addition of integers, figure 6.1 is what Gagné came up with (Richey, 2000, p. 65).

Pre-tests were then designed for students to check which subordinate tasks they could and could not do. Each student was then taught how to do the subordinate tasks they could not do, starting at the lower levels and moving upwards. Once the teaching was done and all students could do all the subordinate tasks, each student was simply given the verbal instruction to complete the task; and – surprise, surprise – almost all of them could.

Why did Gagné call this process a learning hierarchy? Intuitively the answer is a simple one: because you can only do a higher skill once you have mastered a lower skill on which the higher skill depends. And this is precisely what was shown. Students who could do subordinate skill I in figure 6.1 could do all the other skills underneath. Students who could not do skill I, but could manage subordinate skill II could do subordinate skills III, IV and V. There were no students who could somehow do task I and tasks II, but not V (a, b), IV (a, b) or III (a, b) and II (a, b). The relationship between the subordinate skills is asymmetrical. It works in one direction, but not in the other and goes from simple to complex. It starts with simple responses and builds up into chains of responses, which enable multiple discriminations that build into concepts. These are combined into simple rules and they are then combined into more complex rules. You can only get to the complex set of rules once you understand the simpler concepts and rules of which it is made.
This is a different way of working out levels of difficulty from that of Chen’s strategy of ranking items based on the amount of learner error in tests: it works with a logical hierarchical skill structure rather than emergent patterns based on learner responses. In no way does this mean that the hierarchical analysis is always correct. What is needed after an initial breakdown analysis are empirical try outs that test where the skill is located in the hierarchy: ‘whether a particular skill transfers positively to another, or whether they are independent, or whether perhaps they co-vary in their transfer effects’. Gagné notes that his own work on this is primitive: ‘I perceive these to be very unsophisticated compared with procedures I can only dimly imagine’ (Richey, 2000, p. 69).
One can only imagine what he would have made of artificial intelligence combining with ontology-based concept maps. I suspect he would have critically embraced some of the developments. Gagné was not a one-dimensional man who insisted on a rigid following of hierarchical learning programmes. He is clear that there is no one exclusive route for all learners. Individual learners might skip some of the subordinate tasks or use knowledge from a different domain to help complete the task in a different way:

A learning hierarchy, then, in the present state of our knowledge, cannot represent a unique or most efficient route for any given learner. Instead, what it represents is the most probable expectation of greatest positive transfer for an entire sample of learners concerning whom we know nothing more than what specifically relevant skills they start with (Richey, 2000, p. 69).

Chen and Gagné start in very different places: Chen with an emergent logic of difficulty based on error count and Gagné with a general sequence for cumulative learning that works downwards from complex rules to its simpler components. But both wish to develop a learning programme that works probabilistically with an entire set of learners and both use the responses of the learners to inform developments.

Gagné points to three surprising moves individuals could make that break with an expected hierarchical learning pattern: they might jump a level; transfer knowledge or skill from another domain that helps them move differently through the levels; or combine elements in an atypical way to reach a higher level (figure 6.2). He did not have the computational resources of Chen to track individual responses and build them into a larger optional sequential set through probabilistic equations, but he could ‘dimly imagine them’ (Richey, 2000, p. 71).
Gagné was brilliant, but why did he insist that learning hierarchies should deal with intellectual skills and strategies, not the content and concepts of the task? He wanted a final capability (figure 6.2), not understanding of higher concepts. I have learned to be critically respectful with founding fathers as it is often their first visions that are the clearest. However, I have an allergic reaction to skills talk, especially of the supposedly universal or generic kind. I take it to be one of the major blights of our current educational landscape because it mostly destroys detailed engagement with knowledge structures and exchanges it for an empty set of generic skills. But on this point Gagné is unrelenting: ‘[ask] what the individual can do … and avoid … what the individual knows’ (Richey, 2000, p. 71).

It was not concepts he wanted to put in a learning hierarchy, but intellectual skills. Rather than the elementary building blocks of a learning hierarchy, Gagné wanted to get at its sub-routines – its sub-methods, sub-procedures, and sub-steps – at the compositional logics of the larger final capability. Gagné did not want the variable content that gets used by the sub-routines to be the focus of learning hierarchies as this would be mistaking the content structure for the hierarchical driver.

This was not because he did not see the importance of stored, verbalisable knowledge. You need to have a basic vocabulary of concepts otherwise the intellectual skill will not hold in specific instances. Intellectual skill without content is not only empty, it’s often worthless. However, intellectual skills ‘have an ordered relation to each other such that subordinate ones contribute positive transfer to superordinate ones’ (Richey, 2000, p. 74), whereas verbalisable entities do not necessarily have this relationship to each other. Intellectual skills go from simple to complex, whereas verbalisable entities can be learned in all sorts of different orders and ways. It’s where skills build on each other that you have both positive transfer from simple to complex capabilities and cumulative learning that builds continuously upwards. If you get a learning hierarchy right, then learners who achieve a correctly developed set of subordinate skills radically increase their chances of being able to do the superordinate skill. It’s almost a learning fairy tale where what seemed impossible to do as a final capability comes naturally after all the steps have been worked through. You will always need to add to learning hierarchies the content and concepts needed for specific understanding and practice, but what drives positive transfer is the proper non-symmetrical ordering of intellectual skills from simple to complex. Completed correctly, when the learner is given the finishing verbal instruction to demonstrate the final capability, Tau finds she already knows everything she needs; and she just does it.

Gagné was clear that the ordering of a learning hierarchy from simple intellectual skill to complex intellectual skills did not have to determine directly the ordering of the actual learning process in real time (Richey, 2000, p. 75). The presentation sequence could be different from the learning hierarchy. This is not just because learners do surprising things (like jump levels, make idiosyncratic
links and bring in insights from other domains), but because intellectual skills are not the only things learners do. They have to learn verbal information like concepts and terms; cognitive strategies that assist in the self-management of learning; smooth and errorless performance of motor skills; and attitudes that help drive actions in positive ways. None of these other learning outcomes work in strictly hierarchic ways. Verbal information tends to be learned best when presented in an organised, meaningful context; cognitive strategies are learned as students encounter different situations that demand self-regulation at different times, depending on the problem at hand; motor skills need continual and repetitive practice; and attitudes come from interacting with human beings who act as role models. Different learning outcomes need different types of instruction to be effective.

Is it possible to work out an efficient sequence of instruction that holds across these different learning outcomes? Such a sequence would hold enormous value for the project to make all the knowledge of the world pedagogically available to everyone because it would provide, on top of a conceptual ontology or learning hierarchy, a way to sequence pedagogically a lesson from beginning to end that all teachers could use. Where would we look for clues to find such a strange creature? Gagné suggests that we first turn to the internal processes of how we learn and, in 1970’s terms, gives an account of working and long-term memory, executive control, and reinforcement that harmonises well with our own account in chapter 4.

Following reception of incoming stimuli, information is registered very briefly in one or more sensory registers, then undergoes feature analysis or selective perception. The information next enters short-term memory where it can be stored in limited amounts for only about 20 seconds. Here it may be rehearsed and is also subject to semantic encoding, in which form it enters the long-term memory. Information from long-term memory may be retrieved back to a short-term form, which is in this case viewed as working memory. Working memory (conscious memory) is where various combinations of new and old information take place … Executive control [is] a means by which the learner exerts control over the other processes of learning and memory … [R]einforcement takes place … [where] the after-effects of successful performance have their well-known effects on subsequent performances (Richey, 2000, pp. 113–114).

If this is how the internal process of learning works, then surely an external sequence of instructional events could support and influence it. How would this external sequence of instruction work?

First, the attention of the student is drawn to the topic (1) and the learner is informed of the objective for the lesson (2). Prior learning is recalled and activated
(3) before the distinctive new elements are demonstrated (4) and the learner engages in the process of learning the new material in an organised way (5). The learner then tries to show, in some kind of way, that sie can actually do what has been learned (6) and informative feedback is given (7) before a final assessment of the performance is undertaken (8) and further practice and applications given to integrate the skill into existing practices (9). This element of further practice is crucial as it results in automatisation of basic skills and releases attention to focus on the development of higher level thinking processes.

Not all of this sequence of instructional events has to happen explicitly in every lesson as often elements occur implicitly in the flow. And some of the events happen very differently, depending on whether the learning outcome is working with a motor skill, attitude, intellectual skill, verbal knowledge, executive function, or some combination of them. But it still provides a way of setting up the external flow of a lesson in a way that works with our internal processes of learning.

Lessons do not happen in isolation: they combine in larger goals or whole tasks, and these consist of numerous objectives that mix with each other, often involving a combination of verbal knowledge, intellectual skill, executive control, attitude and motor skill. It means that an instructional designer cannot simply rest with the intricate details of a learning task, but has to look at the larger goal behind the various elements and then work out how to hold them all together. Gagné only dealt with this late in his intellectual career (in collaboration with Merrill in 1990) when the necessity of a structuring frame was recognised. Learners would need a frame or schema for the underlying purpose behind a number of lessons to hold. This frame would help them work out when and how different skills and knowledge are needed in pursuit of a more integrated set of goals in a larger enterprise. Gagné was not able to take this forward as he died in 2002, but this question of how to combine various learning objects into a larger whole task framework continues to puzzle. Two very different answers have been proposed in the last twenty years. The first is a radically egalitarian model that pushes for each small learning object to stand on its own feet, independent and free, enabled to combine and intersect with whatever other learning objects happen to resonate with it. The second is a more structured model that proposes a whole task framework holding all the elements together in a co-ordinated pedagogic sequence.

Learning objects

The atomistic idea of independent objects freely interacting with each other depending on the case at hand has been around since Democritus, but its current learning object digital form was mooted in 1992. Imagine a teaching scenario where you have a whole course to put together, but do not want to waste time re-
inventing the wheel when other teachers have already done many of the elements in interesting, creative and pedagogically insightful ways. At what point (if any) in the imaginary scenario sketched below would you start to feel uncomfortable?

Your first option is to go on the Web and find raw media objects (songs, sound bites, illustrations, diagrams and text) and stitch them into your course. On the one hand this is the simplest of activities: you search the topic, find an interesting example and use it in your own lesson. These raw media objects are the easiest of elements to re-use in different contexts. But you will also find other teachers have taken these raw objects and used them to illustrate the same concept or process in which you are interested. Let’s call this an information object. They save you time as they have already worked the raw media object into a basic pedagogic unit that you can use, rather than having to do the pedagogic work yourself. It might be an introduction, a concept, a principle, a demonstration, an activity, or a summary within the topic. These information objects can be pulled together to deal with a specific learning outcome or objective, and this would give you a learning object. Learning objects are still specific enough to be re-usable across contexts because they deal with a definable outcome. A teacher could at this point use learning objects as a part of hir lessons and benefit from the collegial work of hir peers who have put these learning objects on the Web for re-use. A Salman Khan video on adding fractions, for example, could be used as part of a lesson. A number of these learning objects could now be stitched together as a full lesson object: the whole lesson consists of different learning objects put together in a useful order. These lesson objects could be combined with other lesson objects and then used as a full course object over a term.

As a classroom teacher I start to feel uncomfortable at around the learning object level. Anything larger than this feels as if the teacher is being somehow irresponsible and unfair to hir learners. Behind the sense of irresponsibility lies the failure of the teacher to adapt the lesson to the contextual demands of the class. Learning objects can still be used in adjustable ways within a lesson, but a whole lesson object would probably run roughshod over the particular demands of the learners and the school. A whole lesson is too large and context-bound a unit to be plonked into any classroom in the world, unless it was part of a bigger course that was designed from beginning to end. At the learning object level there is still freedom to move and adapt, and a teacher can use the learning object in fruitful and interesting ways. At a lesson level this freedom disappears. It also becomes exceptionally difficult to combine different lesson objects from across the Web into a course object. Each lesson on the Web would have its own starting and end points, its own developing logics, its own assumptions about what has gone prior and is coming after. The only way out of this problem is either to accept that the unabridged course needs to be designed from the bottom up and presented as a whole on the Web; or that learning objects are the largest one can go if you desire a mix and match world of pedagogy.
There is a lot of money to be made from either learning objects or whole courses. Websites are now up and running where teachers can sell their learning objects to other teachers. Teacherspayteachers.com is one such site, where resources as small as an information object and as large as a course object can be bought and sold. The objects are classified into resource types: lesson plans, activities, quizzes, worksheets, white board activities, power points, novel studies, and so on (the resource type list has over a hundred categories.) Each object is cheap to buy, but teachers make money from the number sold with successful teacher designers making small fortunes. At the larger learning object level, there are objects such as ‘learning /ar/ with Pirate Mark (r-controlled vowels)’ that consists of a 38-page set of lesson plans and activities, comprising a Pirate Mark book (pp. 3–9), Pirate Mark sentence strip cut-outs (pp. 9–16), a recording sheet for listening activity (p. 17), Pirate Mark single page poem (p. 18), literacy centre game (pp. 19–22), art project templates (pp. 23–26), whole group treasure hunt activity (pp. 27–30), Pirate mark /ar/ reminder picture (p. 31), sample lesson plan (p. 32), and so on.27 It costs $5. The seller’s nickname is Babbling Abbey. She had 9 257 followers on 7 November 2012, 791 votes (all glowing with comments like ‘arghh! This is a treasure’) and a number of other products for sale. What makes the site work so well is the way it categorises the learning objects by grade level, subject, resource type and price as well as a number of other categories. Each resource has a metadata description that defines the object on a number of levels and depending on your search criteria it either gets thrown up for you to peruse or not.

The reason why I chose ‘learning /ar/ with Pirate Mark’ is that although it is a large learning object, it is not a course. It focuses on one skill (ar) rather than a whole reading programme and can be broken up and used in all sorts of different ways. Planning a whole course over an extended period is a very different endeavour. It was at this point that Gagné ended his career without being able to take it further. One learning outcome is hard enough to design for: what of a complex task or competence that takes months or years to master and involves numerous skills and concepts that combine and intersect in all sorts of different ways? How would you make this available for anyone to access any time and be automatically responsive to the student?

Massachusetts Institute of Technology (MIT) took a bold step forward in answering this question by freely making available its courses on the Web. As of the middle of 2014 it has over 2 000 courses visited by close to a 100 million visitors (http://ocw.mit.edu/about/site-statistics/monthly-reports/MITOCW_DB_2014_03.pdf). You can go to many of them and start immediately. I chose
Foundations of Biology (Eric Lander, Robert Weinberg, Tyler Jacks, Hazel Sive, Graham Walker, Sallie Chisholm and Michelle Mischke) as it is one of the most recent courses on the site designed for independent study. It is not simply a set of lectures recorded on video and uploaded to the Web. The course has lecture videos, learning activities like interactive concept quizzes, problem sets that can be completed on your own, answer sets to check your responses, problem-solving video help sessions taught by MIT teaching assistants, lists of important terms and definitions, suggested topics and links for further study, and exams with solution keys. These are structured in a clear and explicit way with a clear statement of learning objectives, a lecture video, a check yourself test and then another video with a check yourself test, before doing a set of practice problems to embed the information and skills, a list of further studies, and extra useful links that give other examples and applications. The whole session is embedded in a previous/next lecture series.

But that is not all. Running down the left hand side of the Web page is a social sharing site where students can join study groups, post questions and responses, and join the community of learners using the courses. If you are active on the open study group site you get rated and rewarded for your answers to questions. I joined the Foundations of Biology study group and was, as of 7 November 2012, a hatchling, with a zero smart score, zero problem solving and zero team work. The other person online was Sam who had a 99% smart rating, with 71% for team work (for helping 641 students, 438 of whom became fans), 99% for problem solving (answered 2 835 questions and received 1 074 medals) and 64% for engagement (studied for 240 days). Other universities like Stanford, Yale, Harvard and Berkeley also have open ware sites. We are back with the Salman Khan model, except that now whole universities are engaging in the project.

With the massive expansion of open courseware, it was only a matter of time before someone came up with an app for it and this is what Irynsoft has done. The idea is simple: turn your smartphone into a virtual classroom by pulling together and making available the open ware lectures provided by reputable institutions such as MIT and Stanford on your phone. While you participate in the course, you can google elements and issues and make notes, all on your phone while sitting on the bus. The company has a similar app specifically for the Khan Academy and for MIT open course ware. You have a genuine opportunity to learn whole courses over semesters and years. You might not get the degree and you do need to be able to afford a smart phone or have a computer with access to the Internet, all of which are serious issues. But such a monumental opening of sophisticated, organised knowledge and skills at the highest of academic levels has to be celebrated, even if its early incarnations result in massive drop out rates. If it’s easy to access then it’s easy to leave.

It’s not only knowledge that is becoming more accessible – the technology to design and manage the process of making these courses is also simplifying
and becoming more user-friendly all the time. Competing with big universities and companies designing these online courses are individuals at home, with a computer, resulting in an online explosion of systematic introductions to all the knowledges of the world. You can find my own cottage industry attempt to introduce education at www.waynehugo.co.za – one of them being an online introduction of this book.