The self-organising imperative: The adaptive learning potential of virtual microscopy

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Adaptive forms of pedagogy utilise hypermedia technologies like the WWW to dynamically structure a student’s interaction with course content allowing for individual variations in learning styles, cognitive attributes, content sequencing, navigation, differing media modalities, and levels of complexity. Across a range of disciplines at the University of Queensland we have introduced Virtual Microscopy (VM) since 2005. VM is a new digital imaging technology that transforms a glass slide into its high-resolution digital equivalent. As well, we have collected survey data on student responses to this pedagogical innovation that has been overwhelmingly in favour of VM but not at the expense of the traditional light microscope. While not obviously a form of adaptive hypermedia pedagogy, VM can certainly be utilised in such a way so as to ease both staff and students into this truly student-centred form of learning. Using a counterfactual-simulation method, this paper conducts a self-examination of our introduction of VM with a view to making a more thoroughly conceptualised transition from the didactic tradition of learning to an electronically articulate student-centred one.

Keywords adaptive hypermedia learning, virtual microscopy, simulations, human-computer interface, virtual reality

1. Introduction

Our acceptance of technology fosters the belief that we have a right to be cared for; and further, that we will judge every product and service in our lives according to whether it makes us feel well cared for. Technology takes its cue from medicine, which, when it cannot cure, seeks to relieve suffering as efficiently as possible.

Jonathan Franzen [1]

It is perhaps not surprising that American novelist Jonathan Franzen identifies a link between technology and medicine in terms of curing our ills and relieving us of our physical and mental suffering. If the wider medical fraternity is devoted to addressing our suffering from those ills, those engaged in the field of medical education are devoted to curing us of our ignorance, or at least ministering to our lack of knowledge in the field. Obviously, it is in medical education where these two ideas (educational technology and medicine) are structurally and conceptually entwined. Both arenas are rife with debates over their make-up, procedures and outcomes and this is especially so on the specific question of e-learning [2-4]. More widely, an often-repeated complaint about technology is that it creates an unwarranted intrusion of machine mediation into any given relationship, one that sometimes comes at the expense of the human factor.

In a wide variety of contexts, however, the human/technology interface has been with us since at least the discovery of fire. In our own era the widespread take up of electronic technologies since the invention of Morse code and telegraphy in the 19th century have presented us with both a potentially stalemating risk and a Promethean opportunity in transforming the course of medical education in the 21st century. In this transition from literate technologies — usually understood as a didactic, supply-led, and a lecture/classroom model of education [2] — to electronic technologies — a wide variety of more demand-driven techniques and practices referred to as e-learning [5] — it would be a serious mistake to take the latter’s alleged therapeutic properties at face value.

It is equally, if not more than likely that electronically mediated forms of education strongly favour the possibility of generating a self-help, or a self-organising imperative, one compelling us to find out the information we need for ourselves. Specific instances of this electronically arbitrated self-organising ethos are social networking websites PatientsLikeMe and 23andMe, where people with multiple sclerosis, mood disorders, HIV, and Parkinson’s Disease, share information about their predicament in the hope of both furthering and participating in the medical research process itself [6]. Ranged against an often-plentiful array of contradictory viewpoints in a globally digitised educational arena, our embryonic knowledge worker enabled “Globo sapian” students [7] will have to deal with a vast multitude of data sources pertinent to both their pedagogic and medical interests. Considering ourselves first and foremost, and acting as a self-organising entity in our own immediate and always “emergent” informational and educational contexts [8], might then be the more plausible way forward for both the teacher and the student of e-learning.

Since at least the late 1950s, when George A. Miller [9] published groundbreaking work on the subject, we have known of our cognitive limitations when trying to incorporate too much information. While electronic techniques and technologies both help produce this overload and are good at sorting through it, in the end it is our own individual responsibility to mark out what it is that we want and need to learn. In short, when it comes to e-learning, a self-organising imperative is more appropriate in a data saturated and globalised world. Arising out of computer-centred...
cybernetic theory, self-organising systems are a significant element of the New Sciences, which also encompasses developments like fractals, bio- and nano-technology, chaos theory, complexity, systems theory, genomics, emergence, among other components [8, 10-13]. The New Sciences are also very much encapsulated in an ecological point of view, which is not simply an environmental understanding but a way of acknowledging the almost infinite variety of nodal connections between a whole host of knowledge disciplines and ideas that previously were viewed as separate and autonomous in literate forms of education [14, 15]. Self-organised, adaptive thinking can also be allied to its social, political, and technical contexts as much as to the processes of abstract logic or learning practices per se [16]. As learners and teachers imbued with electronic technologies we cannot afford to ignore these larger developments in science and ecological, connectionist forms of thinking vis-à-vis the production of knowledge and the influence they might have on medical education. This is especially important when introducing novice undergraduates to microscopy.

2. The Problem in Context

Virtual microscopy (VM) is quite obviously an e-technology, one that is increasingly accepted by the medical fraternity as an educational, diagnostic and research tool. There is now a wide range of studies on the various educational aspects of VM delineating its introduction in a variety of tertiary contexts across the globe [17-22]. This collection of scholarly work on the pedagogic benefits (and otherwise) of VM also includes studies we have conducted, studies that have marked out our own contextually specific introduction of this recently emerged technology and student responses to it [23, 24]. VM at the University of Queensland (UQ) in Australia has been introduced across the fields of medicine, dentistry, biomedical science and veterinary sciences using an Aperio Systems hardware and software package in digital pathology [25]. VM is a digital technology that scans the traditional glass slide and transforms it into a high-resolution digital equivalent. Conceived in 1997 by the Computer Science Department at the University of Maryland and the Pathology Department at Johns Hopkins Hospital in Baltimore, Maryland [22], VM is a relatively recent addition to the medical technology landscape. While VM technology is not in wholesale use at the moment, it is gaining traction as a method of microscopic analysis across a broad range of medical and educational contexts. It is another electronic technology among many in such contexts and as such serves as an emblematic indication of the changes occurring in medicine and education.

Broadly speaking, our own research could be summarised by saying that students enthusiastically embraced VM while also expressing disquiet about the eradication of tutoring in light microscopy. It is this latter statistically more ambiguous finding of our research, that has caused us to pause and reflect more deeply on the introduction of VM and its wider exemplary status in e-learning focused curriculum renewal over the longer term. VM and light microscopy are not mutually exclusive learning techniques/technologies though. Rather, the techniques and technologies of the past (in this case light microscopy) are not simply eradicated by the introduction of a newer, updated variation or innovation. The confluence produced by the integration of a particular technique/technology in the arena of learning carries over, evolves, sometimes even mutates into the subsequent era. This observation is a variation on Marshall McLuhan’s idea that the content/structure of a past media form being the potential model for a subsequently new media technology [26].

In the great majority of cases involving both human and natural environments, it is the evolutionary carry-over or mutation (of ideas, technology and DNA, for instance) more than the singular revolutionary break that serves as the most common attribute of change. This most likely occurs in education as well, although it is equally clear that some educationalists cling to past techniques and technologies, sometimes with an unparalleled zeal, which in some respects neutralises ongoing innovation on the part of teachers who already operate under the influence of an electronically mediated pedagogy.

In the highly social contexts of education this hangover of traditional techniques and technologies can serve as both inhibitor and liberator in the complex process of coming to understand how e-learning might best be utilised in a dynamically unfolding pedagogical situation. Undoubtedly, a feeling of communion exists when a pedagogic technique and technology go hand-in-hand and produce the desired outcome, that is, deep learning. Analogue technologies like print and the light microscope were at one with teacher-centred, didactic forms of literate-style pedagogy and in many respects were regarded as timeless, beyond change, a point reiterated by Jean-Claude Carrière [27] when he writes that, “The very act of writing is dangerous, for it carries with it a kind of time-honored prestige which is very often its only justification. It is written, therefore it is true; therefore I will do nothing more to it.” In a text-based, teacher-led pedagogic framework then, knowledge is sometimes considered timeless, unchangeable, and occasionally even theologically sacrosanct. This framework is generally regarded as “universal” and imparted in exactly the same manner to every student. Of course in educational actuality the wholesale adherence to such a stringent model did not always exist in practice. Nonetheless, a much more rigid conception of education existed under the didactic, teacher-led model of the literate tradition. As high literate educated teachers ourselves we come under the influence of this long tradition in education even though we may sometimes fight against it.

This deeper reflectiveness on our part led us to acknowledge an error in the introduction of VM technology into the curriculum. What we had done was merely change one technology — the light microscope — for a newer digital computer based one. We always consciously considered ourselves as interactive, electronically tuned-in teachers rather than didactically frozen in a print literate styles of pedagogy but because of the pressure of too many tasks across
administration, teaching/research, community engagement, along with our own aforementioned literate schooling (primary, secondary and tertiary), we had not thought deeply enough about the possibilities that this new digital tool allowed for. This realisation made us return to this new technology once again and ask deeper, more thoroughly informed pedagogical questions of it.

In introducing VM into our programs, we did not fully utilise the features of the Aperio VM viewing software — *Imagescope™* — freely downloadable from the company’s website [25]. In this software there are a number of annotation layers (useful for documenting a collective dialogue about a given digital slide), a tracking tool, measurement indices, variously shaped tools to mark out a region of interest and a facility to label its critical features. It also has the capacity to replicate the whole slide or a region of it as a .jpg or a .tiff file and subsequently export the results to another program, and there is even a built-in teleconferencing facility. We introduced none of these tools in the development of learning exercises tailored specifically to VM although we highlighted the presence of these features to students while demonstrating the system. In effect, we were not “modelling” the new technology for the students, as Will Richardson [28] suggests doing in relation to introducing blogs, wikis and podcasts into educational settings. Naturally enough we are now attempting to conceptualise learning activities centred on these tools. Finally, the central question then became: How will we constitute our educational programs so that they, in both the short and long-term, arise directly out of, and in communion with, the electronic techniques and technologies that have become such a critical part of the educational environment?

### 3. Adaptive Hypermedia Learning

In thinking through this central question, adaptive hypermedia learning continued to materialise in our research. The term “adaptive technologies” is sometimes applied to learners with physical or mental disabilities [29]. However, the term “adaptation” itself is usually defined in a Darwinian, biological sense and could be summed up by saying that it is the ability of an organism’s function or structure to change in relation to its environment or context. This is primarily a biological viewpoint though, the relationship between a physical entity and its habitat. The term “adaptive hypermedia learning” places the emphasis of adaptation unambiguously on a pedagogic footing.

There is a long history of adapting teaching methods to variables among learners that goes back at least to the Greco-Roman period of the fourth century BC [30]. In the current era, use of the term “adaptive hypermedia” arises predominantly in the work of Peter Brusilovsky [31, 32] and refers to computing technology that adaptively mediates between the learner and the content of what is learnt. Adaptive hypermedia learning, as it is spelt out by Brusilovsky and others, brings an artificial intelligence, machine learning angle directly into the heart of communication and information technology focused, electronically mediated educational contexts, Brusilovsky [32] writing of this process that, “Adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user.” An adaptive hypermedia education then does not differentiate between able and disabled learners, potentially making the distinction redundant, at least in terms of learning. Indeed, as an educational model it is the logical outcome of a student-centred paradigm. In short, every student’s adaptive learning potential is pedagogically and technologically modelled on his or her own unique learning and personality styles, cognitive capabilities, motivations, and preferences [33-36].

This burgeoning field of adaptive hypermedia learning also resonates with the shift “from literacy to electracy” [37], which is, in part, a transition from the scientifically static objectivity of the print literate tradition to the more “heuristic” [38], flexible capacity, that is, the self-organising, student-focused learning of electronically mediated forms of education. Heuristic forms of learning place the responsibility for learning very much on students themselves. In short, we wanted to more thoroughly question our own teaching practices in introducing VM while simultaneously analysing (and begin planning for) this larger tectonic evolution to more adaptive, student-centred, electronic forms of education that will most likely come to fruition at some time in the future. This evolutionary change from the more fixed position of didactic forms of a literate education to a more flexible, blended, student-centric model envisaged by a malleably conceived conception of an electrate education though will not be without its pitfalls. The transition is and will continue to be difficult. Nonetheless, this broader rethinking requires a methodological framework in tune with its electro-centric aspirations.

### 4. The Counterfactual Simulation Method

In our own previous discussions on the introduction of VM we related this technology to the already mentioned emerging field of electracy largely because it is both an electronic technology and an e-technique imaging the microscopic world [39]. It is entirely appropriate then that a concerted effort is made on our part to think through the long-term future of these pedagogic changes with a method that is electronically appropriate. Conceptual rigor is still an important component of both educative and research processes in electronic styles of knowledge even if associational forms of reasoning are at their heart [38]. The foregoing left us in a dilemma. In short, we wanted to extend and deepen both student engagement and our understanding and analysis of this transformed pedagogical environment, not to
mention think about how to make provision for long-term planning in order to put our professional programs on a future-ready footing. But how were we going to do that? How were we going to frame and thus order this mélange of disparate ideas and data? From an empirical point of view, we now have conducted 14 student surveys across the already mentioned disciplines since 2005, amounting to a total of 649 student responses. The more empirically inclined survey method proved useful for looking at past practices but was less than helpful when examining the future, or for examining contexts in a state of dynamic change.

What if, then, we were to counterfactually question our largely positive survey results? The counterfactual method works by positing an actual existing entity or occurrence and then working against it with an imagined but plausible alternative [40]. The rubric of evidence-based practice is mostly unquestioned in scientific and medical contexts. The assumptions surrounding verified evidence, though, might be more properly brought into question in pedagogic contexts. As a form of evidence, the student survey method provides empirical verification/rejection for a particular hypothesis. But by being confirmed as an empirical actuality, might any given verification of any particular hypothesis be orientated towards an already existing element of the past rather than be orientated to a possibility in the future?

Furthermore, might counterfactual thinking brought into contact with this empirical evidence be a useful method via which to question the validity or otherwise of a given investigation, especially where it is necessary to think about future possibilities? Thinking counterfactually involves a method of understanding that utilizes this given statistical evidence as a means of both thinking with and against it, in which case all constitutive elements are required in order to come to more fully comprehensive but still solidly reasoned conclusions. Given the counterfactual method’s propensity for both virtualising and simulating scenarios it is also highly applicable to electronic techniques and technologies [40]. Brian Rotman [41] goes so far as to say that, “… computer-enabled simulation in the sciences — a virtual form of experimentation — is now recognized as a third investigative mode alongside the time honored ones of theory and experiment.” In this specific context, a counterfactual simulation then allows us to work both with and against established forms of knowledge as a means of thinking about pedagogical change.

The survey data furnished by our students (henceforth referred to in a generalized manner for the sake of brevity) provides us with the substance against which a counterfactual simulation proceeds. This method also provides a means via which an adaptive hypermedia-learning environment might be compared and contrasted with these student responses to VM. While VM is most certainly not an adaptive technology (it does not change in response to each individual student’s engagement with it), the counterfactual method is here used to test the hypothesis that if VM is utilised in a more thoroughly elective educational sense, might this potentially lead us more directly to a student-centred pedagogy in an actual adaptive learning environment sometime in the future?

5. Into the Cockpit of the Counterfactual Simulation

As mentioned, in previously published work we established our students’ acceptance and enthusiastic embrace of VM while simultaneously expressing their reluctance to see the end of tuition in light microscopy [23, 24]. In light of this evidence, let us return firstly to another closely related question we asked of our students across all our surveys: “Using the virtual microscope positively enhanced my learning of the material in this course”. All our surveys returned 75% agreement, or over, with this statement. Undoubtedly, VM has made an unequivocally “positive enhancement to student learning”. At the risk of stating the obvious, students are highly enthusiastic about this electronic, digitally configured means of learning about microscopy. This grounding attribute of VM, and the obvious success of its implementation even in a didactic fashion, should not be lost sight of in the following discussion.

From a more counterfactual point of view though the figures associated with the questions dealing with the ability of VM slides to be integrated with Blackboard™, UQ’s Learning Management System (LMS), are a case in point. All the survey responses were over 70% in agreement with the success of this integration. On one occasion there was even 97% agreement. Clearly students were more than happy with the integration of VM with the LMS. Looked at through the lens of adaptive hypermedia learning though, LMSs have advantages and peculiarities that need to be questioned. Weber and Brusilovsky [42] note that LMSs like Blackboard and WebCT “… have zero adaptivity but they provide something that their customers appreciate most – versatility.” Versatility means that LMSs can show links, organise quizzes, allow the teacher to upload files to their course site, provide for a/synchronous communication with and among students, along with other learning tools and activities. However, by being proprietary systems they cannot adapt; that is, they cannot change themselves to suit each student’s individual profile, elements of which we mentioned earlier. In essence, proprietary based LMSs continue with the didactic method of learning/teaching by creating a course site that the teacher controls. So in those universities that continue to utilise a proprietary LMS, the evolution of adaptive hypermedia learning will continue to be thwarted.

Already in a previous paper on VM we grouped together two questions on “resolution” and “magnification”, emphasising the notion of the “quality” and “technical clarity” of the microscopic imagery produced by the technology [24]. From an adaptive point of view we need to take this more basic analysis a step further. It can now be clearly stated that the definitional clarity achieved by digital technologies far surpasses that of analogue technologies. This is illustrated clearly, for instance, in the triumph of digital photography, the MP3 format, and DVD/Blue-ray media, among others, over their older analogue predecessors. The definitional clarity of digital technologies means the more
bytes there are the greater the definition and hence the greater the quality of any given digital learning object. This increase in definitional clarity is a key factor in understanding the move from the more didactic formulations of print literate culture to the more virtual/simulated, image-based forms of an electrate education.

In grouping together statements on the “resolution” and “magnification” potential of VM (and any other statements on quality) we are suggesting that high quality production values are a critical attribute of digital learning objects, an attribute to be achieved before fully fledged adaptive learning can proceed, although Clark [2] offers a differing point of view in relation to “image fidelity”. The support for the high production values of VM was overwhelming, all our survey responses coming in above 70% agreement. This concurred with our view of the outstanding image quality provided by Aperio technology. The multimodal character of digital learning objects [43, 44], that is, they are able to variably incorporate the modalities of text, images, and sounds also further enhances this notion of high production values. This feature, in turn, allows “adaptive hypermedia systems … a choice of different types of media with which to present information to the user” [32]. In short, there is a significant increase in the notational complexity of the actual digital artefact not seen before in literate based pedagogy.

Once definitional clarity of the digital learning object and its production costs meet on an equal footing, simulation or virtual reality forms of education (training in an airline pilot simulation is emblematic here) become more feasible, and more pertinently, believable. And in simulated, game-based learning, and 3D virtual reality forms of tuition (especially important in medical contexts) there is a direct connection with adaptive forms of education [45]. Augmenting a student’s knowledge of some specific element of print-based course content as a real one, these already mentioned electronic modalities allow for the virtual experience of a particular procedure: pulling or drilling into a tooth, inserting a scalpel into human flesh, taking a biopsy, for example. With the advent of electronic technologies, the virtual is not simply an imaginary process but a kind of “real virtuality” [46], one where students can experience a medical procedure without the anxiety of conducting it on a real person.

The capacity for deep learning in the 3D virtual reality, simulation, and gaming experience is very much dependent on the definitional clarity brought to the encounter by the technology; the more bits and bytes, the greater the emotional and thus affective intensity of the educational experience. While a “Writing based epistemology values abstraction, the separation of the observer from the observed, the subdividing of confusing wholes into comprehensible parts” [47], a holistically composed, real-virtual educational experience is much more thoroughly articulated through these already mentioned adaptively structured, electrate forms of pedagogy. The adaptive, e-learning potential of VM then should lead us in this latter direction, not simply repeat the instructional, one-way, reality formulated methodologies implicit in literate technologies.

There are a number of tools within the slide viewing software — Imagescope™ — that could help encourage and structure a quasi-adaptive electrate learning experience. The tracking tool, for instance, can create a record of a student’s movement around a given slide that can then be saved in the annotation layer. This annotation tool, in its turn, is especially good for recording a collaborative engagement among a group of students, being able to record a textual discussion and/or a graphical display on the histology or pathology of a slide in a number of different layers; so a group of six students, for instance, could each be allocated a different annotation colour so that the group could produce a collective response to a particular question posed by teaching staff or even by students themselves. The log files that are automatically generated by an engagement with the software could also be used as a means of assessing student contribution to the collaboration. There is also an image adjustment tool that can alter brightness/contrast and colour balance. Furthermore, there is a digital slide teleconferencing tool, tailor-made for a structured lesson in telemedicine, one that could draw on the collaborative skills developed in the annotation tool. That our lesson plans have not incorporated these tools into our assessment guidelines is an indication of the still persuasive power of the didactic tradition even in those of us who are thinking otherwise. If we recall that the textbook and the essay, and the student assignment, had to be developed in the literate tradition, we should remind ourselves that there are a whole host of electronic tools across a range of hardware and software platforms that have to be pedagogically conceptualized into lesson plans. The potential of VM can only be nurtured if we apply our specific content knowledge to the available tools within the technology. This will in turn also help faculty staff (in conjunction with computing personnel) to develop localised software tools for uniquely configured learning/teaching objects in their own contexts while also keeping a lookout for established digital learning objects that are transferable across contexts [48].

While there are a large number of topics that could be addressed in this debate there is one issue central to this evolution from a didactic, literate sensibility to an electrate educational one. In hypermedia educational environments like the WWW or a digital learning object, navigation has come to augment, sometimes replace, a linear, sequential reading as the means via which a learner experiences course content. Largely because electronic environments organise data in a predominantly spatial rather than a temporal fashion [44], it is easy, as Brusilovsky [31] indicates, to “get lost” in them. This is also a widespread complaint about the datasphere in general. However, as we pointed out in our earlier discussion [23], navigation in Imagescope™ is very simple and an overwhelmingly positive agreement was garnered from our students in relation to this issue. As magnification levels change, an image of the entire slide sits in the top right hand corner allowing the student to know precisely where they are at any magnification level.

This overwhelming agreement though blinds us to the serious issue of navigation in electronically mediated learning environments of a more complex character. While this agreement is certainly a positive factor, what happens when a
student comes to navigate through a number of screens and/or there are a number of open screens on the desktop? This is especially difficult for the novice student because “Most of the offered links from any node lead to the material which is completely new for them. They need navigational help to find their way through the hyperspace”. The point remains that computer mediated, adaptive forms of learning not only adjust themselves to a learner’s cognitive style and their level of engagement; they offer up different modalities of instruction i.e. voice, image or text; as well as respond to a student’s variable interests, goals, preferences and even shifts in a learner’s specific environment; but also part of the package is the possibility of navigational assistance through course content [32]. The ease of navigation in Imagescope™ then might prove deceptive when students come to an adaptive learning environment constituted by a wide diversity of data viewable through multiple windows and at multiple levels of complexity, and with course content that changes in relation to your engagement with it over time. The failure to properly navigate a digital learning space has dire psychological consequences for learners in that it results in a loss of engagement and subsequent mastery, over both the ability to traverse the learning space and the course content they discover there. A comprehensive understanding of navigation (for both faculty staff and students) is therefore essential to the conceptualization, production and use of digital learning objects of both the fixed and adaptive variety [49]. Finally, given the importance of “visuospatial thinking” [50] to electronic forms of learning this shift to an adaptive, electrate style of education might also require more detailed instruction on the meta-learning aspects of spatial cognition.

It is now appropriate to recapitulate this contradictory relation between the nostalgia our students have for the analogue light microscope and their well-documented enthusiasm for VM. This discrepancy might be explained in the following way: Both students and faculty staff are still very much influenced by didactically disseminated literate practices as they are promulgated in infancy, through childhood, home-life, primary, secondary and tertiary schooling, all compounding during the course of a lifetime. This continuing influence is now contrasted with more highly pervasive electrate practices dominant in the use of television, cameras, mobile phones, iPods, laptop computers, the WWW etc., and the “network associational” logic [38], and “adaptive thinking” [16] that they promote. While certainly there is a possible synthesis between literate and electrate practices, it is equally possible they form a sometimes contradictory combination. So even if students are more attuned to an electrate environment of learning than are their teachers — the “digital immigrant, digital native” argument [51] — there is still a traditional hangover of literate practices they (along with faculty staff and support personnel) have submerged in their make-up.

All the foregoing suggests the need for an adaptively individualised model of tuition. An electronic pedagogy is, after all, thoroughly constituted as a differential paradigm, a matrix like stratum manifested in a whole host of technologies and techniques. Not only is a truly electrate, adaptive pedagogy a potential threat to faculty staff but it is also potentially threatening to students, even educational administrators. It should not be assumed that a student population supposedly native to electrate, digital practices in domestic and popular cultural contexts will automatically take responsibility for their own self-organised learning in tertiary contexts, a proposal advocated by at least one section of the medical education fraternity [52]. Given the deep-seated history of the didactic, injection and literate model of education we should proceed with a degree of caution as we move to a more student-led, flexible push-pull approach to learning and teaching.

6. Moving Into the Future

It has been suggested that adaptive hypermedia learning is better suited to complex subject matter and higher level postgraduate students [53]. By engaging in some meta-learning and teaching, both with ourselves and our students, faculty staff might better encourage the attributes of adaptivity, cognitive flexibility, constant innovation, lifelong learning and teaching, and an emphasis on the spirit of discovery in undergraduates as well. The study of microscopy is potentially complex subject matter. It offers an entry point into the subatomic world beyond human vision, a world that is a significant component of the New Sciences. Building a reshaped pedagogic bridge from this invisible world to the novice undergraduate will potentially increase the likelihood of bright students taking up a scientific or medical career.

While the term “adaptive hypermedia learning” is relatively new, the term “hypertext” (in contrast to the more recently coined hypermedia) can be traced back to Vannevar Bush’s seminal essay, “As We May Think” [54]. In the history of computing this essay is justifiably well known in that it articulated an idea called the “memex”, a device that could store and link up a vast bank of information and make it interactively accessible to users on a desktop. Over time, the concept of the memex morphed into hypertext, then hypermedia. In contrast to didactic forms of education, adaptive hypermedia forms of learning and teaching are substantially student-directed, foregrounding the multitude of differences that learners bring to the educational exchange. This adaptivity creates the conditions for a more dynamic interchange between learner, content and educator.

There is no coincidence that knowledge work and the computer have arisen to prominence together; much like the assembly line and manual labour in the early 20th century, they are the yin/yang of the modern 21st century work environment across a wide range of professionally orientated, knowledge intensive contexts. It is nonetheless clear that tertiary education personnel will need to instigate substantial changes if these suggested innovations in adaptive forms of education are to proceed in a more fully-fledged manner. These anticipated conceptual, technical and administrative changes will not appear out of nowhere; first they need to be imagined (virtualised and simulated), then planned,
financed and practically put in place. They certainly will not come about by unthinkingly replacing one technology and/or technique with another or by letting a naïve conception of pedagogical change lead us by the nose into the future.

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References
