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Chapter Title: Electronic Media as a Catalyst for Enhancing Metacognition

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Synopsis:

Empowering human intellectual capability through the strategic assembly and presentation of electronic information and media holds great promise for educationalists dedicated to improving student learning. Digital learning environments will eventually evolve into 'intelligent thinking' systems that interactively respond to individual learning needs and assist learners to derive meaningful understanding, create new knowledge, solve problems on demand, and enhance their higher order analysis and metacognitive thinking skills.

Keywords:

metacognition, information, media, learning environments, intelligent interaction, knowledge construction, higher order thinking, critical analysis

Electronic Media as a Catalyst for Enhancing Metacognition

Abstract

Where learning in the future is concerned, it is argued that for students to competently manage inconceivable quantities of information, as well as interpret, understand, synthesise, and create new knowledge, radical new approaches to electronic learning environment design are required that intelligently interact, respond, and adapt to the learning needs of the individual.

Digital technologies have enabled exploration of the inner workings of natural and human phenomena in ways that until now have not been possible to imagine. As a result, there are signs of a noticeable shift in what humans learn and how they learn. However, without a thorough examination of the relationships that link technology, communication, media, and human/computer interactions to cognitive development, the power of electronic learning environments will not be fully exploited. For each level of advancement in learning and knowledge aspired to, new and increasingly more complex design strategies are required to ensure learners gain deep understanding and are thus afforded greater opportunity to apply higher order thinking and analysis skills to the construction of new knowledge.

While it is difficult to determine the full extent of change in the short term, there is little doubt that current perspectives on how to cultivate higher order analysis and metacognitive thinking skills through digital learning environments will be insufficient for addressing the complexities of an information-focussed society. In order to deal with the emerging issues and challenges presented by an economic imperative to manage and process exponentially expanding sources of digitised information and media, new design strategies are required that support an increasing demand for innovative knowledge creation and advanced information management skills.

Introduction

Before information and communications technologies (ICT) became a prominent factor in determining educational design, Gardner and Hatch (1989, pp 4 - 9) proposed: “we need to be able to formulate new questions, and not just rely on tasks or problems posed by others. We need the ability to learn in new ways, to evaluate our own progress, to be able to transfer knowledge from one context to another”. Most important they emphasised, are the “so-called metacognitive skills – an understanding of guiding principles, of what really matters, and the ability to filter out the growing flood of stuff that matters least”.

The preceding extracts highlight the scope of this chapter, which is to explore how sophisticated online learning environments may be designed and constructed to foster higher order analysis and metacognitive thinking skills. The need to cultivate such skills point to the specific information and media literacy issues examined in this chapter. The fact that Gardner’s proposal was made more than twenty-five years ago has not escaped attention, and suggests that the issues raised in this chapter have proven to be more difficult to resolve than he originally imagined. The series of theoretical discussions and arguments pursued in the pages to follow are intended to convince the reader that recent advancements in ICT are opening up previously unimagined opportunities for learning (Dreher & Williams, 2006; Candy, 2004) requiring a thorough (perhaps revolutionary) reappraisal of the goals and purpose of education.

If we look beyond the many debates and promises surrounding ICT in education, it is clear we are witnessing an information explosion of historic proportions. Despite a wide divergence in perspectives, few would contest the view that the current exponential growth in information is largely attributable to the combined effect of ICT and the Internet. This in turn raises the complex issue of how to teach learners to competently manage and process vast quantities of ICT generated information and media. In contemplating the complexity of managing electronic information and media, compelling questions arise about the impact of the Internet and its related technologies on individuals and society in general. One potentially useful hypothesis is that a new set of properties has emerged, the combined effect of which is greater than the sum of the contributing elements. The insights to be gained from an analysis of these emerging factors (emergent properties) will add to current understanding on the especial, yet little understood educational needs of a world that is almost totally dependent on the use of ICT.

Past researchers such as Jonassen & Wang (1993) observed that merely providing content and showing learners structural relationships is not sufficient for attaining higher cognitive performance. They emphasised that "what matters most is the construction of personally relevant knowledge structures". This means that learners must actively engage with learning materials presented at varying levels of complexity, and provided access to resources that match or accommodate their individual preferences and goals. Jonassen & Reeves (1996) further demonstrated it is possible to design software support tools that assist to organise, restructure and represent what learners know and that such tools can support their investigations and thereby enhance the learning experience. Other researchers favour extending or changing learners' cognitive schemas and learning approaches through the provision of 'intelligently' managed learning materials (Jonassen, 1988). These somewhat varying conclusions point to the core aim of this chapter, which is to argue that if learners are to develop effective information and media literacy skills for deriving new meanings and understandings, they require advanced cognitive support tools and highly adaptable, interactive learning materials that support the development of these skills. In contemplating the potential such tools and materials hold for learning, a number of crucial factors and issues arising from the delivery of electronic information and media require discussion.

Critical Thinking as an Essential Skill

As the quantity of available information increases, the pressure to sift through and discern the 'signal' from the 'noise' intensifies. The most widespread source of information today is the Internet. Yet, even as far back as a decade, much of the information provided on the Internet was unsourced, unreferenced, and often unreliable (Gipson, 1996, p 9). While the education system teaches students how to find information and in some instances, how to evaluate the value of that information, the capacity to make judgements of true, false or plausible, or useful or not useful, to assimilate information from multiple sources and subsequently make independent assessments about its intrinsic worth have become essential skills (Slotta & Linn, 2000). In a world where access to information is immediate and inexpensive, the new challenge for educators and students is to learn how to deal with the complexity of information and accurately discriminate amongst the myriad of alternative sources (McDowell, 2002; Taylor, 2002).

Traditionally, the main sources of information have centred on textbooks, encyclopaedias and magazines. In recent times, the new technologies have introduced an unparalleled diversity of alternative information and media sources that are readily accessible through the Internet and

from compact discs. Instead of structuring these ubiquitous resources in linear (sequential), discipline-bounded formats, keyword search tools assist to locate and view globally distributed unstructured sources of digitised information and media at will. Hyperlink technologies permit embedding highly interrelated, non-linear connections among all forms of electronic information and media. Each information source, ranging from the printed page through to interactive electronic media is presented from multiple viewpoints, in turn requiring the user to apply sophisticated analytical and interpretive skills (Feltovich, Hoffmann, Woods, & Roesler 2004). These skills are required for the simple reason that information and the knowledge produced from it do not always come with a guarantee of quality. Without such skills, critical discrimination between valid information and inaccurate information is at best difficult and at times, impossible.

While it must be acknowledged that the Internet in its current form is a good medium for delivering static knowledge and can seamlessly incorporate strategies that aid cognitive encoding and retention, the goals of learning are inherently much more comprehensive requiring complex higher order thinking, critical analysis, problem solving, decision making, and knowledge construction skills. However, in confronting the need for educationally effective learning outcomes, we also uncover the hidden challenges of using the Internet to deliver electronic information and media. Burbules and Callister (2000, pp 71-85) sketch out the core capabilities that define critical users of the Internet:

- critical users need to possess multiple strategies for finding information on the Internet
- critical users need to find ways to be selective about what they find
- critical users must develop more effective, multilayered ways of judging credibility
- a very different sort of critical reading is required to determine what is 'missing', using one's knowledge to infer gaps and to question identified false trails and omissions
- apart from locating sources of useful information, users must infer where and how the emphases and omissions of content (including how it is organised) may serve the interests of particular groups over those of others
- the skills of critical 'hyper-reading' across multiple media sources are required. Critically examining images, music and video is not the same as reading printed text as the particular way multimedia juxtaposes text, images, and music in itself is another dimension of reading, and
- critical users must engage in discussions about information to highlight the reflexive nature of reading.

Thus to be 'critical', means that for learning to take place, the learner must be exposed to new or contradictory information, then process or transform the newly acquired information through analysis, reordering it to extrapolate, interpolate or convert it into new knowledge. This process of transformation signifies the cognitive manipulation of information for deriving new knowledge or understanding. Nonetheless, in order to derive useful or innovative knowledge, it is necessary to judge or to have previously judged the value of the information at hand. This analytic process requires the active application of thinking strategies that support the cognitive tasks of organisation, encoding and retention. Learning and understanding is the result of how these cognitive processes assist to engage the higher order thinking skills of analysis, problem solving and critical thinking. Such skills extend our cognitive abilities to construct abstract concepts that emerge from the application of formal and informal logic, conceptual analysis, and critical interrogation and evaluation, all of which underwrite the iterative construction and reconstruction of understanding and knowledge.

Genuine learning (and conscious awareness of the innate cognitive processes) is achieved by encouraging learners to be active participants in the process of knowledge acquisition; to be engaged in the selection and transformation of information; and to construct hypotheses and

modify those hypotheses in light of new or inconsistent information. In essence, the core preoccupation of critical thinking is to discern flawed information from important, useful, or meaningful information by replacing uncoordinated or distorted thinking with critical thinking strategies based upon reliable processes of inquiry. Through critical discernment and reasoning, an information literate individual is equipped to (Association of College and Research Libraries, 2002, pp 4 - 5):

- determine the extent of information needed
- access the needed information effectively and efficiently
- evaluate information and its sources critically
- incorporate selected information into one's knowledge base
- use information effectively to accomplish a specific purpose
- understand the economic, legal, and social issues surrounding the use of information, and access and use information ethically and legally

The preceding ideas are not new. Bruner once explained that learning involves three almost simultaneous processes. In the first instance, the learner requires exposure to new or contradictory information. Secondly, for learning to take place, the learner must process or transform newly acquired information through analysis, reordering it so that it may be possible to extrapolate, interpolate or convert it into new knowledge (knowledge construction). Finally, effective learning requires evaluation, not only to ensure that the method used to derive meaning from information is suited to the process, but equally important, as a means of identifying the learning strategies adopted during the process (Bruner & Anglin, 1973, p 397).

In today's ICT-focussed world, critical interrogation of information and electronic media assumes greater significance in that it provides insights into how to acquire, record, organise, retrieve, display and disseminate information whilst online. In turn, these insights determine how learners select, filter, interpret, evaluate, and synthesise information and media in their efforts to understand and construct knowledge. Thus, the acts of recall, understanding, application, analysis, evaluation, and the creation of knowledge represent an epistemological hierarchy of a cognitive information processing skills taxonomy (Anderson & Krathwohl, 2001).

Judging the Value of Electronic Media

Since their introduction, the prevailing view has been that digital technologies provide faster, cheaper and more convenient tools for the production, storage, and dissemination of text and media. In recent times, the digital capabilities of computers are such that there have been profound effects on the organisation and type of content produced and as a consequence, on the strategies applied to reading, analysis and interpretation. The accepted notions of sequential linearity and hierarchical organisation for structuring written text has been replaced with hyperlink technologies that permit new conceptual designs based on multi-linearity, connected nodes, and networks (Landow, 1997, p 2). Words, sentences, and text fragments are not only linearly structured in a predetermined sequence, but can also be laterally structured in a multidimensional, networked matrix of threaded pathways that allow readers to instantly select and display alternative resources.

The design of hyperlinks is much more than just a new organisational approach, it also influences the types of information that are organised. This is because the structure and meaning of information and media alters as the organising system subtly introduces different contexts and meanings (Hill & Hannafin, 2001; Siemens, 2004). Burbules and Callister (1996,

p 2) add another dimension to this perspective by reasoning that "… because knowing depends upon the meaningful organisation of information, new methods of organisation imply changing forms of knowledge." In the digital world, form and content therefore, is interdependent.

In the past, facts, concepts and viewpoints were cognitively 'connected'. Now, it is possible to visually represent and dynamically link the same elements by rearranging their relationships to generate alternative informational structures. There is however, a downside to these new structural 'liberties' in that the relationships that connect electronic information and media can be effortlessly organised and redefined to create new 'wholes' and thereby intentionally or unintentionally reveal new insights and meanings, or even impose new contexts that may engender notions of non-existent 'realities'. These new complexities give rise to the issue of how to generate new knowledge in light of the capacity for interlinked information and media to influence context and meaning, which in turn raise deeper questions about the very nature of knowledge. Given that understanding and knowing depend upon the meaningful organisation of information, then new methods of organisation imply a manifest potential to alter accepted boundaries and forms of knowledge.

It is worthwhile to consider that the manipulation of electronic information and media may not only provide new explanations of what we perceive (or assume) to be reality, but could also yield the key to manipulating 'reality' by altering the relationships among discrete information components. By this, I refer to the pedagogical strategy of 'contextualisation'. In the extract to follow, Duncan (2001, p 8) presents a model of reality that challenges our accepted view of the world:

> ... for any individual in the universe, reality is represented by those elements of information which have a probability of trueness that exceeds the threshold of conscious/awareness for them. To some degree it can be argued that reality also includes those elements of information that have reached the centre portion of this model, having crossed the threshold of existence in the subconscious mind, but having not reached the threshold of conscious awareness.

Assume for the moment that all available electronic text and media are interlinked. In this scenario, it would be possible to represent knowledge structures in an infinite number of ways. In theory, every user could explore, interpret and understand information and media according to their own unique cognitive frameworks and learning preferences. It is here that we gain an insight into one of the difficulties students may encounter when engaged in constructivist learning activities. Whereas an objectivist approach would assist to preserve the connections that can be "tested against reality", constructivist learning permits the creation of new structures using hyperlinked representations which may or may not be factual. Thus, hyperlinked information and media introduce a hyper-reality that is not always evident in the real world.

Russell (2007, p 7) advanced the notion of an Internet that is evolving into a vast globally networked repository for all human knowledge where data and information is no longer stored in libraries and inside human minds, but is also distributed amongst tens of millions of host computers located throughout the world. A link displayed on any of the billions of pages available on the web provides instant access to any number of interrelated pages. In the same manner that human recall can take the form of a thought, a visual image, a sound, or a memory, a link on the web may call up text, images, sounds, video, virtual reality, or any combination of media. Not only does the web afford an unprecedented capacity to deliver

information on demand to a global population, one day it will facilitate the movement of elements of information between the ‘real’ and the ‘not real’. Thus, in an information-dominated age, the core issue many learners will need to come to terms with will be the accuracy or the ‘reality’ of information. Projecting further into the future it is conceivable the software engines that drive the web will eventually possess the capacity to automatically form new associations, synthesise information to create new knowledge, and solve problems on demand.

Already there is evidence to support the preceding conjectures. Consider for example Frand (2000, pp 16 - 22), who in attempting to understand the essential characteristics of recent generations, identified what he refers to as "ten attributes of an information-age mindset", each reflecting the values and behaviours of the current generation. The third attribute refers specifically to their view on reality:

> Reality is no longer real: There is a general recognition of the fact that those things which appear real on the television and the Internet may not in fact be real as they appear. The concept of “real” can be interpreted in one of two ways: that the sender is who she/he claims to be, and equally vital is ‘knowing’ that the content is accurate. For young people, a virtual reality simulation (such as a flight simulator or a holographic tour of a city) can be interpreted to be as ‘real’ as the actual, physical experience.

As we move from the world of ‘physical reality’ to the realm of ‘subjective reality’ where individuals define their perceptions in terms of meaningful cognitive relationships, it is crucial to question our assumptions about the relationships between technology, media, learning and reality. When the potential for technology to alter our perspectives on teaching and learning is taken into account, combine this with the constructivist position in relation to the divergent interpretations of reality made by individuals, then add the value of learning theory for providing a framework for deriving accurate representations of knowledge, it is apparent there are many complex factors to consider. Consider for example, if information is indeed the fundamental focus of human activity, then what we presently understand as ‘an information system’ and ‘information technology’ will change as we learn to understand the essential nature of information and media and how to apply such resources to learning and the construction of knowledge.

If the interrelationships that bind digital technologies, human interactions and communications, and cognitive development to information and media literacy are not fully appraised, then the design of electronic learning materials has the potential to devalue proven ways of knowing and deriving meaning. If for example, a linked pathway reveals information that differs substantially from what is familiar and readily understood, the resultant experience can lead to confusion and detrimental consequences for the learner’s confidence and attitude to learning. The current tendency toward instant, superficial consumption of digitised media could replace thoughtful reading with unquestioned acquisition of information where there is an assumed equivalence to learning and the ability to analyse critically. The prevalence of a predisposition in current generation students for summarily ‘surfing’ between different sources of information and scanning simply to locate what is immediately engaging could further hinder their capacity and inclination to distil ideas from which to derive depth of understanding. Then there is the issue of substituting disciplined cognitive analysis with the uncritical use of hyperlinked pathways that may not assist learners to understand the author’s argument, or experience, or account of events that is embedded within the original (intended) context.

By design, the structure and format of print-based materials influence learners to think about what they have read and the interpretations formed in the process. In attempting to decipher the content, the learner is afforded the opportunity to stop and reflect on its meaning. Whilst engaged in reflection, the learner actively connects the written word with information stored in their long-term memory, using strategies such as note-taking, list-making, and paraphrasing to comprehend and organise the given material, develop deeper levels of understanding, and to plan, monitor, and evaluate how well he or she comprehends the written material. The cognitive activities of reflection, processing and analysis describe the key attributes of metacognition, or in other words, the process of 'thinking about thinking, knowing what we know and what we don't know' (Blakely & Spence, 1990, p 1).

Herein is an important distinction to be made between two types of thought processes. The first is the way the human mind processes printed material in a step-by-step sequence during which the contents are cognitively synthesised and assimilated into the learner's existing knowledge framework. The second applies to the user of electronic media conditioned to favour sources that are immediately accessible and entertaining (Oblinger & Oblinger, 2005). Since digital media rely on fast rates of presentation thereby evoking constant shifts in focus, a hyperlink-conditioned mind is afforded little or no opportunity to apply the metacognitive thinking strategies needed to assimilate the displayed material into their personal cognitive framework in a coherent, meaningful way. The key factors to acknowledge here are that the printed word affords opportunities to pause, reflect, contemplate, plan, and devise strategies for incorporating new information and ideas into the learner's personal knowledge base. The relatively newer ICT-based learning solutions rarely facilitate such actions. The opportunity to select links at will leads to multiple pathways that are difficult to recall in detail. As a result, the capacity to pause and reflect diminishes, thus hindering the ability to apply metacognitive thinking strategies (Campbell, 1998, p 28).

Regardless of the content type (printed or digital), a well-trained analytical mind applies metacognitive skills to control its cognitive activities: seeking instances where discrepancies in accepted thinking arise; recognising the need to purposefully locate more information on a specific topic; then devising plans to refine and evaluate the learning process. Such thinkers also actively apply appropriate background knowledge to a given task. Lacking such knowledge, they identify where their knowledge structures are deficient and seek informational resources from which to gain the required background knowledge. Metacognitive thinkers also employ a full range of thinking skills, including a capacity to engage in recall, understanding, application, analysis, synthesis, and evaluation (Livingston, 1997; Blakey & Spence, 1990). In light of the importance of the printed word in shaping metacognitive skills (hence meaningful learning), then perhaps an examination of whether 'digitised' information and media may or may not enhance learners' thinking processes is in order. In other words, what strategies could encourage students to act purposefully on electronic information and media?

Implications of Applying Electronic Media to Generating Understanding and Learning

As implied, the provision of electronic information and media requires learners to reflect on new materials, discuss their tentative understandings with others, and actively search for additional information in ways that further illuminate or strengthen their understanding and ultimately, assist to build conceptual connections to their existing knowledge base (Brown & Thompson, 1997, p 75). The latter point naturally applies to the notions of meaning and knowing, which demands further clarification.

As individuals encounter information from different perspectives and backgrounds, and for diverse purposes, so too does meaning change (Leu, Kinzer, Coiro, & Cammack, 2004; McCombs, 2000). The initial meaning of an image, report, or graph is redefined according to context, the learner's prior knowledge and actions, as well as their unique goals and perceptions. This eclectic mix of processes raises the perplexing question of how learning can be supported whenever students are engaged in electronic learning environments given that the meaning of the available information can vary in relation to the intention of the originating author and the multiple perspectives learners form as they select links according to individual interests, goals and needs. To resolve this question, it is necessary to explore the basic concepts of knowing, understanding, and knowledge construction.

Hannafin (1997, pp 256 - 7) defines knowing as an awareness that learning has occurred as demonstrated by the ability to recall or recognise the information contained within a resource, both for individual purposes and for the interpretation of meaning. A great deal of what people learn they know at a superficial level, that is, they accumulate information without exercising depth of understanding, utility, or knowledge.

Understanding involves recognition of the implications of one's knowledge and the capacity to reason, analyse, interpret, think critically and deploy it. Complete understanding encompasses the learner's ability to comprehend varied perspectives, to explain, and to infer new ideas and knowledge using their individual knowledge constructs. Thus, understanding involves a transformation of meaning based upon the associations that match directly with personal experience and prior knowledge. Again, Burbules and Callister (1996, p 7) provide a more precise definition of these notions by explaining that 'learning' and 'understanding' operate through the formation of cognitive connections. Information is not learned as discrete, isolated facts, but instead new information is integrated with existing knowledge.

The construction of new knowledge occurs when recognised relationships are analysed to interpret the implications and meanings that are inherent within the perceived connections (Bellinger, 1997, p 2). The act of deriving meaning is therefore an interpolative and probabilistic process (Bellinger, Castro & Mills, 1997, p 2), a view consistent with that of Bruner. The acts of understanding and knowledge interrelate in that each occurs through the activities of observation, questioning, research, and dialogue, and how individuals absorb, apply, and communicate information. That is, the process by which information is synthesised into new knowledge requires the application of cognitive, analytical, and language skills, which activates retention of information and the formation of ideas and concepts. New additional information and knowledge is generated as these ideas, information and concepts are analysed and synthesised with existing knowledge in an iterative process that leads to new understandings (Daniel, 1996, p 2; Brown & Thompson, 1997, p 75). By sending and receiving information through dialogue and communication, whilst simultaneously processing unknown information to create and store new knowledge, learning transfers from one individual to another or to a group of individuals (Olivera & Straus, 2004; Schwartz, Bransford, & Sears, 2005).

Given the intricate interconnectedness of understanding and knowledge, it follows that as understanding grows so too, does knowledge. As suggested in the previous paragraph, the exchange of ideas and concepts derived through ongoing discourse with other individuals enhances this phase of the learning process, which in turn generates new understandings and new knowledge. A cyclic pattern of cognitive processes is now apparent. The pattern of observation, questioning, research and dialogue includes the retention and absorption of new

knowledge with pre-existing knowledge is repeated through a series of cumulative iterations. It is this cyclic cognitive process, albeit stated in simplistic terms, which results in learning. Note too, there is a need to distinguish the learning of information from the learning of knowledge. On the one hand, learning information requires little more than the ability to recall and repeat (rote learning), whereas meaningful learning requires the cognitive skills of synthesis and analysis to enable the construction of new understandings and knowledge (Ho, 2002; Turgeon, 2002; Zoller & Pushkinb, 2007). Thus, the need for higher order analysis and metacognitive thinking skills is re-emphasised.

The construction of new knowledge is not simply the result of the individual's capacity to act intentionally and purposefully on their accumulated personal experience and understanding. The most creative learning occurs when new material readily connects with what are often complex and multiple links of association. Through this grounded process, knowledge and understanding catalyse, yielding something that previously did not exist or was not part of the individual's prior experience. Such cognitive action may involve forming an inference, solving difficult problems, responding differentially to complex circumstances, forming new connections, or articulating new ideas and perspectives.

In essence, the key factors to note are that learners inherently construct knowledge as they process the information resources provided (or located), pursue their personal learning goals, construct working hypotheses, and create solutions to the problems at hand. As Tan and Biswas (2007) affirm, generating knowledge is what learners do with information and media resources as they define goals, generate hypotheses, and acquire new understandings. The question for now is how to underpin the knowledge construction process with the theoretical principles required to model a design approach that provides for the efficient yet effective conversion of information into knowledge and in so doing, enhance/reflect/mirror the way the human mind naturally functions (Quinton, 2006).

Manipulating Electronic Information and Media to Engender Deep Learning

The design of most information management and learning delivery systems aims to organise electronic information and media in order to facilitate convenient access to learning materials. Their underlying instruction sets and protocols tend to impose explicit organisation on information using preconfigured criteria (some now permit the capacity to specify preferred organisation). Many electronic learning systems permit explicit (hyper) links to resources predetermined according to external judgements of relevance or importance, effectively structuring and connecting the resources before delivery (Rieh, 2002). In theory, such delivery systems support learning by either overtly directing or cueing users to the next segment of information or to alternative information. While this method is useful for certain applications, it can also generate confusion and give rise to uninformative results. This is because learning resources designed for one purpose that are (inappropriately) applied to other purposes may be contradictory to or inconsistent with their original intent and hence unsuited to the targeted learners' needs (Hammer, 2000; Leacock, & Nesbit, 2007). Therefore, it is important to be aware that application and meaning varies according to context and produce varying learning outcomes. Such design may be relevant for example, to instances where the learner is encouraged to apply their preferred learning strategies and construct their own knowledge based on their individual goals and interests (Hannafin, 1997, pp 255 - 8).

In determining a suitable design model for the delivery of educationally effective information and media, a useful start would be to propose that the goal of learning is to assist the student

develop ‘holistic understanding’ through active participation in learning environments modelled on networked systems of learning systems’ (Campos, 2004). For such systems to support the cultivation of enhanced learning outcomes, the model for learning design should be composed of multidimensional, multi-levelled, interconnected, and interrelated webs of data, information (including media) and knowledge. Thus, principles of networked ecologic systems, self-organisation, and properties of emergence are introduced as integral components of learning environment design (Brown, 2002). In this refined model, information and media are not presented in a predefined format, but instead are structured, destructured, restructured, interwoven and interrelated in highly complex configurations (self-organised) wherein all entities influence each other and the value of any is dependent on the purpose and context to which it is applied. As a result, meaning, understanding and knowledge do not emerge as unidirectional, sequentially derived outcomes.

In constantly dealing with large, uncoordinated compilations of electronic information and media, we are habituated over time to believe our knowledge systems are valid (Green, 2005). As a consequence, the need to think more critically is ignored. For example, whenever we encounter a familiar sight such as other individuals, we often perceive them as male or female without considering other possibilities. Alternatively, when confronted with the unexpected or anomalous such a car crash, we make judgements or deliberate on what has occurred. In both instances, varying degrees of meaning are added and therefore each encounter leads to new information, albeit to different levels of detail. Regardless of how often or how well information is obtained and subsequently manipulated, at best it is an abstract representation of ideas. To enable analysis and interpretation, the information presented requires prior knowledge, yet simultaneously it presents a useful building block for constructing new knowledge (emergence). By itself, information does not transform into knowledge, but alters the individual’s existing knowledge, thereby extending the possibilities for deriving new knowledge (Stenmark, 2002). Once again, the skill of metacognitive thinking is brought into focus.

The benefit of associating apparently incongruous ideas or facts is in learning to discern the connections that support meaningful and useful interpretations that give rise to novel and insightful understandings. Thus, hyperlinked information and media afford opportunities to exercise valuable learning strategies as it can assist to highlight ideas and possibilities visually in ways that are not inherent in reading and reflection on print-based materials. Hyperlinks designed with a degree of built-in structure may serve as effective bridges or scaffolds to bring learners to the point where they can create more personal and distinctive organisations of the available materials. Alternatively, hyperlinked learning materials that facilitate varying degrees of unstructured and idiosyncratic exploration provide an indispensable learning strategy for students who are comfortable with independent learning activities.

As alluded to earlier, an intriguing example of how information (and media) can be structured to form new and previously unimagined associations is to consider the possibility that all nodes of information are viewed as being equal on all levels, without a hierarchical structure, with none more central or more important than that of all other information. In this view, new and previously unidentified associations (links) form, opening up the potential for creativity and innovation in ways that are not possible using print-based materials. Equally possible however, is the potential for chaos, arbitrariness, as well as the counterproductive and time-consuming exposure to permutations and juxtapositions that are without purpose or application. The key is to determine the conditions under which it is appropriate to free up and

decontextualise each node and thus provide an effective means of identifying useful and novel 'lateral' connections.

Whereas the traditional 'linear' mode of connecting ideas and facts is out of necessity limited to a 'manageable' number or subsets, levelling out and equalising all nodes of information effectively allows for the number of nodes to be boundless. The underlying assumption is that everything is assumed relevant, interesting, or important in some way. By drawing on larger numbers of sources, the range of potentially useful connective relationships increases, in turn diversifying the learner's exposure to meaningful associations. Notwithstanding the potential learning benefits of unbounded, free form associations, the concern is that unstructured hyperlinked structures may not accommodate the needs of all learners (Burbules & Callister, 1996, p 16):

> Teaching children to understand the orderly unfolding of a plot or a logical argument is a crucial part of education. Authors don't merely agglomerate paragraphs; they work hard to make the narrative read a certain way, prove a particular point. To turn a book or document into hypertext is to invite readers to ignore exactly what counts - the story.

As this argument instructs, teaching certain conventions of linear narrative and argumentation is an important aspect of students' learning experiences. However, such structures are not the only means of organising and interpreting information and in some instances may prove to be counterproductive. In the absence of sound educational design, what could appear to be an effective learning strategy may in fact inadvertently preference preconceived interpretations of knowledge. This in turn raises the question of deciding who should select and organise the core learning materials, who will be responsible for defining the criteria for relevance and the relative importance of the selected materials, and who will determine what associative links are most useful. Ultimately, in order to develop deep understanding, learners sometimes need to make personal choices and at other times, there is a need to impose restrictions.

The risk however, is that hyperlinked information and media can either provide too much information with an unbounded structure, or confine learners to a prescribed, inflexible structure that may contain inaccuracies due to the unintended (or even intended) introduction of implicit judgments. Thus, not just any association will serve the learning process. All the while, educators must remain mindful of the fact that there are also certain accepted and well-proven conventions and heuristics that promote meaningful and useful interpretations.

It falls on educators therefore, to understand how students learn and to be involved in the design of learning solutions that not only to assist them to accurately discern the differences between information and knowledge, but also to develop and define the skills required to critically judge the value of information whilst gaining a thorough awareness of how they learn. Only then, is it fitting to engage learners in the construction of knowledge using electronic information and media. Two design strategies offered for consideration include the provision of individualised learning opportunities that enable learners to construct personally meaningful assemblies and interpretations of the given learning materials; and, permit unrestricted explorations of the available materials to reveal the susceptibility of information to form more than one type of association and thereby influence context and meaning. Both these examples focus on the delivery of individualised learning solutions.

As teaching resources become more widely available, it will be feasible to automatically locate and reshape the information and content they contain in a multitude of ways to

accommodate individual cognitive schemas and thereby encourage deeper engagement in the learning process. For example, the application of selected teaching resources (in the form of learning objects) to varying contexts affords an effective pedagogical strategy for enhancing learner understanding. Although in one context a resource may appear meaningless, the act of embedding the same resource in an alternative context exposes the learner to new insights that may accentuate otherwise unknown or unfamiliar aspects of the broader subject area (Longmire, 2001; Hill & Hannafin, 2001). The learner's capacity to understand complex concepts and to generate new knowledge is thus enhanced by designing learning solutions that assist them to connect prior insights and understandings to multiple, at times incongruent contexts through the strategic contextualisation of learning resources and the flexible, dynamic interlinking of resources held in multiple knowledge domains.

Although the notion of individualised learning solutions is highly attractive, it nevertheless is made even more complicated when consideration is given to the distinct differences in generational viewpoints and aspirations. Students of today for example, display a remarkable adeptness at concurrently juggling text, popup-boxes, and hyperlinks – a strong indicator of a transition in culture and cognition leading naturally to the hypothesis that students are developing the ability to operate in complex digital environments and no longer prefer the printed page (Leadbeater, 2004). It is possible we are witnessing the emergence of new cognitive capabilities. What at first may appear to be an inability to focus might in fact be a preference for working with all forms of electronic media. Thus, any attempt to accommodate the skills and preferences of current generation computer 'literate' students will inevitably compel educational designers to think entirely "outside the box" and consider design strategies that are more in line with their expectations and demands.

The development of delivery systems that support genuine individualised learning inevitably raises a number of challenging issues. One area of concern applies to the design and application of flexible, adaptive human computer interfaces (HCI) that interact with and respond to the specific learning needs of individuals. The argument raised here is based on the notion that learning environments in the future should incorporate principles of self-organising systems (facilitated through dynamic content assembly) and networked ecological systems (to enable online communities of learning) that respond directly to learners' input to deliver more comprehensive learning experiences (to produce properties of emergence). In effect, learning environments could evolve into 'intelligent thinking systems' that 'learn' and respond to student input using content interactive features that offer (Barr, Burns, & Sharp, 2005; Wobcke, 2004; Guetl, Dreher, & Williams, 2005; Quinton, 2007):

- 'intelligent' search tools capable of meaningfully interpreting learner input
- the ability to annotate and record ideas online that automatically trigger dedicated 'intelligent agents' designed to seek out and display supporting information
- manual and dynamically generated supplementary materials relative to students' progress, learning styles, and visual preferences
- 'intelligent' interactive cognition support systems that assist the learner to develop metacognitive awareness and higher order thinking strategies, and
- the 'intelligent' display of customised content such as interactive assessments and constructive feedback tailored to students' immediate learning needs.

Instead of simply being a convenient means of accessing information, electronic learning environments of the future must incorporate the capacity to enhance students' conceptual understandings. Electronic learning environment design therefore requires a dramatic rethink; in particular, with regard to the application of 'intelligent', interactive computer enhanced support systems. The design and development of learning solutions that assists students to

cultivate metacognition and knowledge creation skills requires several interrelated areas of research: an analysis of the properties, modelling structures and representations of knowledge domains; methods for managing and transferring tacit and cognitive knowledge; contextualisation of information and knowledge to assist in identifying interrelationships that elicit metacognitive thinking; and, the strategic structuring of information and knowledge that permit flexible navigation using multiple learning pathways. With these goals in mind, the ideal learning environment should assist learners to derive answers to the broad level 'meta-questions' of (Anderson & Elloumi, 2004; MacPherson, 1996; Huitt, 1997): how do I know what I need to learn?; how do I get there?; how am I progressing?; are my goals still relevant?; and what are the best learning models for me?

Strategies that provide partial direction include the adaptation of games theory principles to enhance community interaction and motivation to engage in information and media processing activities that place less emphasis on memorising facts and more on utilising cognitive strategies for discovering knowledge (Pivec & Dziabenko, (2004); and extending the functionality of content repositories to manage highly adaptable, interactive learning materials that deliver more than just static content and assist the learner to organise, reflect, analyse, and synthesise information in their efforts to construct new knowledge.

Conclusions

If students are to experience the type of meaningful learning that prepares them for the challenges of the information age, three convergent factors require deliberation. That is, meaningful learning occurs at the nexus of where cognitive alacrity, learning curiosity, and strategically connected information and media resources combine to create a 'greater than the whole' learning experience. However, the task of bringing all three factors together is not easy. This is because the culture of many (Western) societies today is characterised by fast-paced lifestyles and a desire for instant, visual gratification, which to some extent are attributable to an increasing demand to cope with rapid technological change. These new cultural 'norms' may act as impediments to meaningful learning as indicated by shorter attention spans, an inability to express ideas verbally, a reduced ability to reason analytically, and an absence of complex problem solving skills. Such learning deficits do not meet traditional academic requirements, which may shed some light on why some researchers raised concerns over two decades ago of a 'misfit' between students and their schools while others have expressed concerns of diminishing educational standards. If these learning deficiencies are not addressed then it will become more difficult if not impossible to equip students with the skills needed to fulfil the expectations of the global community. Furthermore, if not examined in terms of learning effectiveness and the cognitive skills required to compete and succeed in a world that is increasingly reliant upon digital technologies, then the goal of cultivating electronic information and media literacy in learners is almost certain to further compound or even create new or unexpected problems to resolve.

The successful transition from formal training to a demanding and unpredictable future is contingent upon ensuring students are taught 'traditional' literacy skills such as critical thinking, rational analysis, problem solving, research, communication and writing. Equally important, is the need for social skills developed through teamwork, group presentation, negotiation and conflict resolution, the provision and acceptance of feedback, active listening, cross-cultural communication, and finally, time and project management. Note again, the implied importance of collaborative learning environments. The acquisition of thinking skills and the conversion of information into knowledge are not isolated processes, but instead

many factors combine to create a learning environment where the requisite skills for an information age can be cultivated. The outcome may lead to the emergence of new (creative) ideas that are attributable to group dynamics forming highly complex, networked interactive synergies or the self-organisation of information and media to suit varying individual and group needs, which together transform the learning experience into something that is much greater than the sum of the parts.

The challenge for the future is to design and deliver learning solutions aimed at not just representing knowledge and facilitating navigation through structured or unstructured information and media using complex learning pathways, but also to develop advanced design methodologies that employ emerging technologies to support the refinement of the higher order cognitive skills of analysis, problem-solving, conceptual thinking, and metacognition. In practice however, the issues and strategies for designing educationally effective electronic learning environments are highly complex and diverse. Without a thorough examination of the relationships between technology, communication, information, media, human/computer interaction and cognitive development, the full power of ICT as an aid to learning will not be realised. To this end, a core focus of all ICT related educational research should aim to identify and explore the benefits of applying advanced learning strategies, design methodologies and pedagogical innovations to the complex task of delivering learning environments that augment learners' information and media literacy skills and address the goals of all individuals. For now, regardless of what the future may hold, it is important not to lose sight of the fact that ready access to information and media does not always equate to being educated, in particular where ICT supported asynchronous and 'distance' communication modes are employed. It is not enough to simply deliver and assume learning will result.

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