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Chronology of Competence Achievement

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ABSTRACT This paper looks at the assessment and evaluation of time factors in on-line teaching and learning. It considers the relationship between levels of expertise (from novice to beginner to competent, proficient and expert), with both learning (the acquisition and synthesis of data to information and knowledge) and time, identifying the chronology of competence achievement.

Keywords: Education, Knowledge, Competence, Chronology

Introduction

The concept of time is a key issue incorporated in most educational theories (Barbera and Clara, 2012), such as: Behaviourism (Skinner, 1968); Genetic epistemology (Piaget, 1980); Cultural psychology (Vygotsky, 1978); and Didactic (Carroll, 1984). This paper looks at the assessment and evaluation of time factors in on-line teaching and learning. It considers the relationship between levels of expertise (from novice to beginner to competent, proficient and expert), with both learning (the acquisition and synthesis of data to information and knowledge) and time, identifying the chronology of competence achievement. Much of this paper's focus is on Higher Education. However, consideration of skill levels (in Section 3) is domain neutral, with an applied example from computer hardware fault diagnosis and repair (Graham, 1990).

In the first section, the temporal and spatial dimensions of learning are made visible through the application of a Time/Space Matrix (Graham, 2010).

The second section looks at the evaluation of learning in relation to time and the acquisition of data, information and knowledge, with some discussion regarding the implications of the temporal characteristics of E-Learning and their impact on the nature of learning and teaching. Examination of the characteristics and the dimension of time in E-learning processes enables the concept of time in educational phenomena, specifically in E-learning processes, to be understood (Graham, 2014).

Section 3 considers the relationship between levels of expertise (from novice through to expert), learning (knowledge acquisition and synthesis) and time.

Finally, Section 4 discusses the findings and draws conclusions on the chronology of competence. Throughout this paper, the terms "E-Learning" and "on-line teaching and learning" are deemed to be synonymous, although a preferred term for both is "E-Delivery" (Graham, 2009).

The Spatial and Temporal dimensions of learning

JISC (2011) defined E-Learning as the process of learning that is made easy and supported by the use of information and communication technology. The technologies utilised can be in the form of a combination of, or all of the following: Computer infrastructures (e.g. laptops, PCs, handhelds, mobile phones, interactive whiteboards and digital cameras); Software applications; Virtual Learning Environments with electronic communication tools (such as Moodle, WebCT with email, discussion boards and chat facilities); and Video conferencing facilities.

Furthermore, Gayle et al. (2003) state that the UK government intends to raise standards in Higher Education by increasing course flexibility to make learning available to a more diverse student population. This is also referred to as Lifelong Learning, making learning more widely available to citizens accommodating all ages of life (Mason and Rennie, 2003). It includes the acquisition and update of individual knowledge, interests, abilities and qualifications from infant years to post retirement, promoting citizens' adaptation and participation in all areas of economic and social life. Lifelong Learning also involves valuing the different forms of learning which encompass the Higher Education offered by the universities.

Technological advancement is therefore exploited to facilitate the Lifelong Learning agenda reaching out to all ages, especially the demographic of the technology age. This mode of learning is based on internet technology, so it can be perceived that the concept of E-Learning is driven by the need to catch up with the fast growing internet technologies used for Lifelong Learning.

Similarly, Mason and Rennie (2003) identified features such as the call for continuous updating of knowledge and skills and the need to maintain currency with the flood of internet information as motivating factors in E-Learning.

Waterhouse (2005) describes how E-Learning emanated within the professional development context; the technology started with its use for workforce optimisation showing key benefits that E-Learning can offer within the professional field. Examples are the ability to deliver a more robust training experience that is not necessarily classroom based or mere handout material reliant. The E-Learning technology offers the flexibility for users to train at their own convenience, maximising learners' free or less busy time, i.e. downtime leveraging. The free extra times of the learners are utilised to get on the E-Learning system, a pull rather than push system for knowledge and skills.

Waterhouse (2005) further sheds more light on the basic understanding of the E-Learning concept, explaining commonly used terminologies in learning, namely: *Pedagogy*, "the art of teaching"; *Andragogy*, the art of supporting adult learning or teaching within a self-directed learning environment such as Supported Open Learning (SOL); *Traditional Environment*, defined as a classroom based environment; and *Distance Learning Environment*, defined as a non classroom based environment, also sometimes referred to as Open Learning Environment (OLE).

In agreement with the previous authors, Mason and Rennie (2003) similarly offers good advice on the concept of E-Learning within the academic pedagogy, providing meanings and theories behind some terminologies such as E-Learning and lifelong learning, which relate more to educational environments.

Similarly, Tomei (2007) further expressed the influence of ICT in the form of multimedia configuration on the process of teaching and learning. It was noted that classroom based teaching does not fully engage the students in visualisation tasks and virtual experiments. The use of graphics, audio, video images and animations supports the effectiveness of the teaching process, enhancing knowledge transfer into experience within the students' mindset.

Interactivity is promoted via the aid of multimedia learning tools, expanding the range of graphical environments. Better control is given to the learners in this environment over the consumption rate of the learning materials offered. Learners are able to assimilate at their own pace, promoting interest in the particular subject area. Tomei (2007) further noted that self discipline and high commitment is required on the part of the students, as tutors are less able to influence this because it is not face-to-face (f2f) classroom based.

Findings of workshops on E-Learning (Graham, 2011) have found that debates about whether or not technologies for E-Learning should be employed have been forfeit; E-Learning is now part of the organisational strategy of many universities in the UK. The arguments for and against E-Learning have been rendered academic, "with e-learning now high on the agenda of the UK Government and of all educational sectors, it is clear that e-learning is here to stay" (Kathy Wiles, Senior Adviser LTSN Generic Centre, 2007); the genie is well and truly out of bottle. The prevalence and promotion of E-Learning is still politically rather than pedagogically driven (Graham, 2007; Hadyn, 2006; Wannermacher, 2006), and the fact that mapping the E-Learning strategy to an organisation's business objectives is strategically the first stage is a strong indication of this stance (Graham, 2009a).

A nine stage Transnational Framework for E-Learning (Graham, 2010) was developed and represents the culmination of several studies. The original motivation for the work was the perceived failures in E-Learning (Samuels, 2005). The perspective was that of Interaction Design (formerly known as Human-Computer Interaction), noting that E-Learning is merely another form of Computer Mediated Communication (CMC), and as such is amenable to the application of a Computer Supported Cooperative Work (CSCW) framework (Benyon, 2010; Dix et al., 2004; Sharp et al., 2007). The application of a CSCW framework to E-Learning formed Stage 6(ii) of the Transnational Framework, where differing delivery mechanisms of learning are shown within a Time/Space matrix in Figure 1.

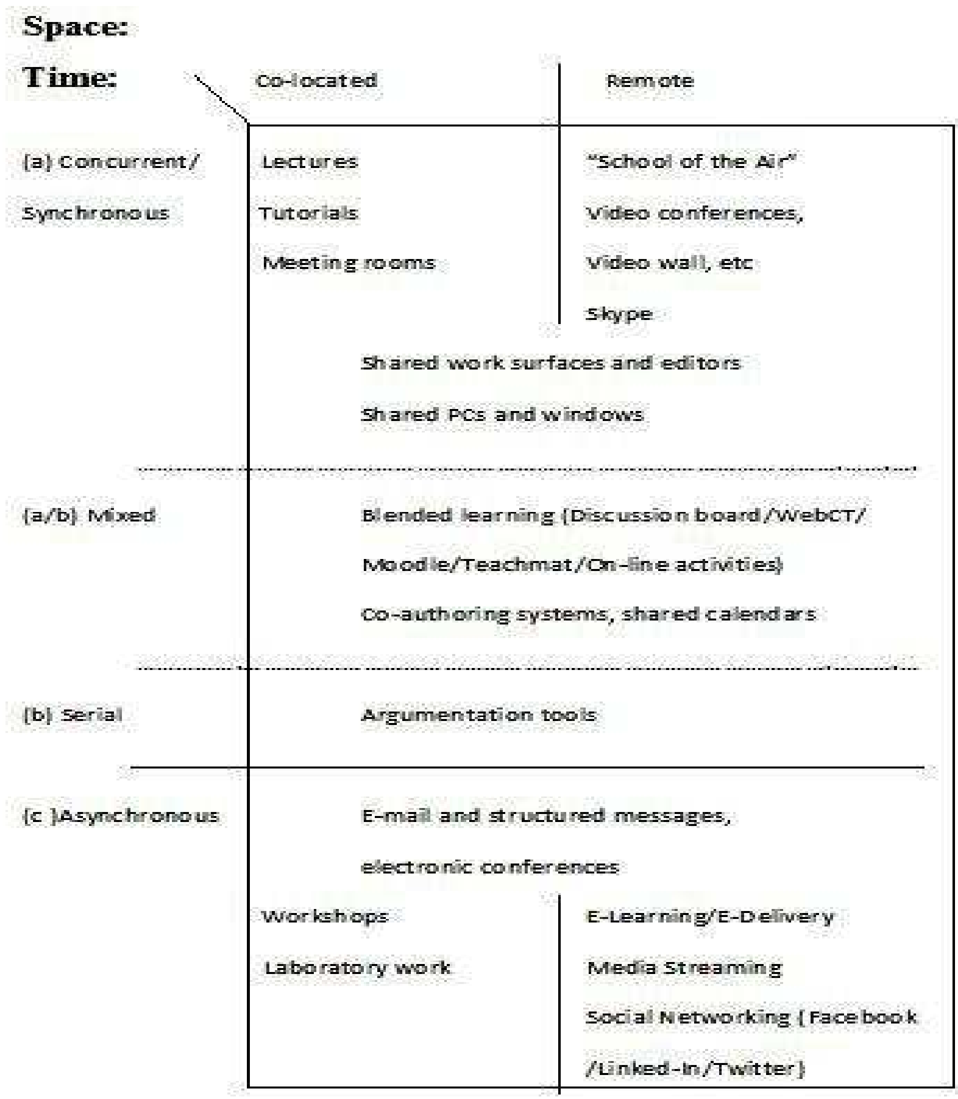
Traditional learning is shown to be co-located and synchronous. Laboratory work can be synchronous, but is usually asynchronous as depicted. Blended learning is both temporally and spatially mixed. The use of video conferencing and Skype are illustrations of a general trend for Blended Learning, especially for externally linked institutions. E-Learning or E-Delivery aspires to be remote and asynchronous, however E-Learning is seldom so "pure", and in practice some face-to-face (f2f) elements are usually found to be present (Graham, 2013). Recognising E-Learning to be another form of CMC means that E-Learning is subject to the inherent weaknesses of CMC in terms of interaction design; lack of visual and audio cues, synchronicity, grounding, back-channels and feedback.

The refined Time/Space matrix also shows Social Networking, categorized as for E-Learning to be remote and asynchronous for the same reasons; these are the purported strengths. It is acknowledged that Facebook may also be used asynchronously. The relevance of Social Networking is its increasing deployment in E-Learning, although it could be argued that E-Learning is happening within social media. There is an increasing use of Media Streaming for lectures, etc.

Figure 1 lists E-Learning, Media Streaming and Social Networking as separate entities in the Time/Space Matrix, with E-Learning as defined by JISC (2011). However, the boundaries are becoming merged as are the technologies. Australia's successful School of the Air is categorised as synchronous and remote; it is essentially schooling via the radio. The temporal significance of learning is demonstrated by the School of the Air, where radio communication, whilst remote, is synchronous, and exhibits few of the problems of on-line learning.

Blended Learning blends traditional f2f and on-line delivery mechanisms, such as combining f2f lectures with Virtual Learning Environments (VLEs) like Moodle. Blended Learning represents a blend, or perhaps a compromise, between traditional f2f learning which is co-located and synchronous, and the remote and asynchronous communication indicative of E-Learning.

Figure 1: Stage 6(ii): Learning in a refined Time/Space matrix. Revised from Graham (2013), p. 47.



The Time/Space Matrix clearly depicts the temporal and spatial attributes of the different teaching delivery mechanisms and associated digital media (essentially forms of CMC) and their inherent strengths and weaknesses. Most learning is now Blended; often traditional synchronous f2f delivery involves the use of some asynchronous remote digital media, whilst on-line delivery (E-Learning) often includes some supporting synchronous f2f elements to overcome problems associated with Salmon's (2004) Access and Motivational, and On-line Socialisation stages. Using both on-line and f2f delivery modes exploits the respective advantages whilst avoiding the absolute shortcomings of each. There is an issue of responsibility (McNay, 2013) when tools such as Moodle are used for co-located synchronous teaching in the classroom. Is the tutor delivering the material, the lecturer who originally produced the material (the VLE content designer), or the system (Moodle) responsible for the delivery of the material? It has been reported (Hearne, 2011) that some tutors simply log-in to the VLE and present the tutorial literally as given, simply making the appropriate mouse clicks with no greater level of tutor engagement than that provided by the on-line delivery system. The responsibility for the delivery of materials (whose) has itself temporal as well as spatial implications. With whom is, and therefore where and when the responsibility for the delivery of material may reside, is possibly in a different part of the matrix to where and when the material originated.

Time and the acquisition of knowledge

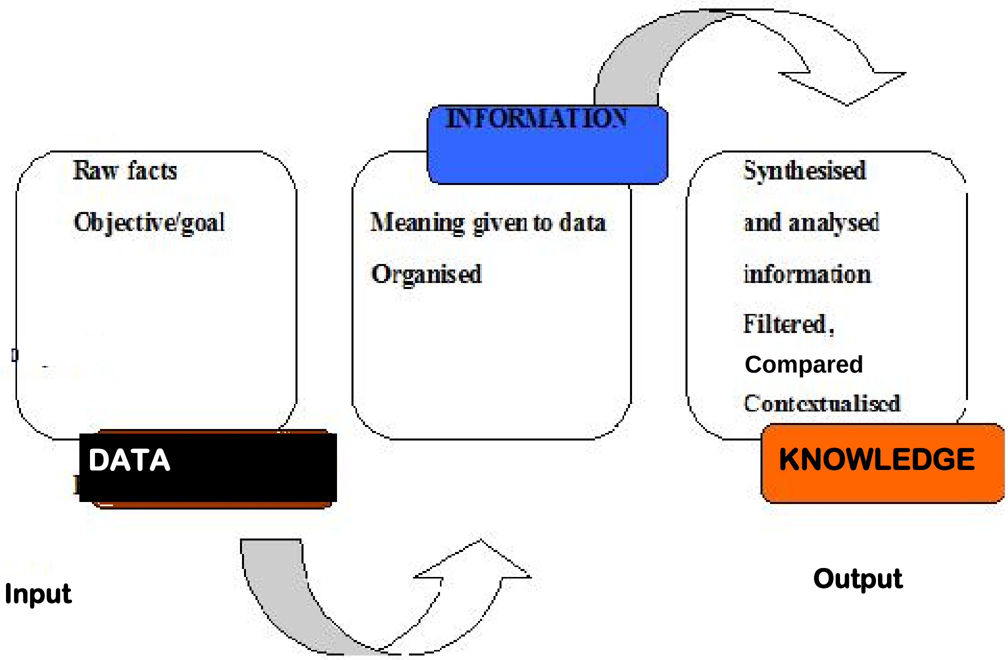


Figure 2: Information Processing View of Learning

The learning process can be viewed as a form of information processing, as suggested in Figure 2 (Graham, 2014). Although humans are not information processing systems, there are many aspects of this model which are relevant, as an Information Systems (IS) approach is usually applied to the design of VLEs. Humans do appear to take in raw data with a specific goal, to organise the data so that it has meaning and to analyse this information (compare and contrast, etc elements of Bloom's (1956) taxonomy) to a more structured form, namely knowledge. The processing of data into knowledge relates to understanding; a cognitive process argued to be visible only through external behaviour, hence the advocation of the term E-Delivery rather than E-Learning (for a fuller exposition see Graham (2009)).

Life insurance example

Data:	Mr. (male) John Smith died in London, England on the 1st February 2003, aged 74 years. Mr. (male) Peter Brown died in Stafford, England on the 23rd September 2003, aged 69 years. Etc.………
Information:	The average life expectancy of men in England in 2003 was 73 years.
Knowledge:	The predicted life expectancy of men in England in 2013 is 80 years.

Figure 3 (Graham, 2014) adds the temporal dimension to this model. As shown in the Life Insurance Example, data is absolute, and with a value independent of time. This is not true of information; information must be timely if it is to be informative and of value, and usually deals with the now (present). It is suggested that knowledge synthesis, on the other hand, can take place at any point in time post the processing of information, relying on past, historical information (recent or otherwise) to enable future predictions; for example, the employment of data mining: historical (past) data and information mined to make (future) predictions and hypotheses. Although knowledge is employed in the present, the creation of new knowledge is perhaps associated more with the past (events) and the future (predictions).

Figure 3 suggests the temporal relationships between data, information and knowledge. The suggested steps involved in learning are the presentation of external data (facts) currently achieved by VLEs to varying degrees; their organisation into information and subsequent analysis to knowledge (which requires understanding) must be cognitatively achieved by the individual student. The independent learner has always and will always exist. The independent learner learns independently of any tutor, s/he is self-organised, motivated to learn for its own sake, and is capable of assimilating data, acquiring information, synthesising and structuring this into knowledge. S/he is not born a domain expert, but an attribute of an expert is the ability to structure and create new knowledge, so it is likely that independent learners are Expert Learners. Tutors, VLEs and learning strategies must accommodate all learners, not just the independent learner. A good teacher provides "learning cues": The tutor may, for example, ask questions that prompt the student to organise the data (content) presented, thus gaining information. S/he may suggest contemporary tailored comparative examples to enable this information to become knowledge (make appropriate associations and predictions). These attributes are currently well beyond VLEs, if only because tutors (who are experts) have a huge "knowledge base" and digitizing such a knowledge base and the inference engine (software mechanism for making inferences) would prove an impossible task in terms of the state-space search alone even for limited domains (Graham, 2014).

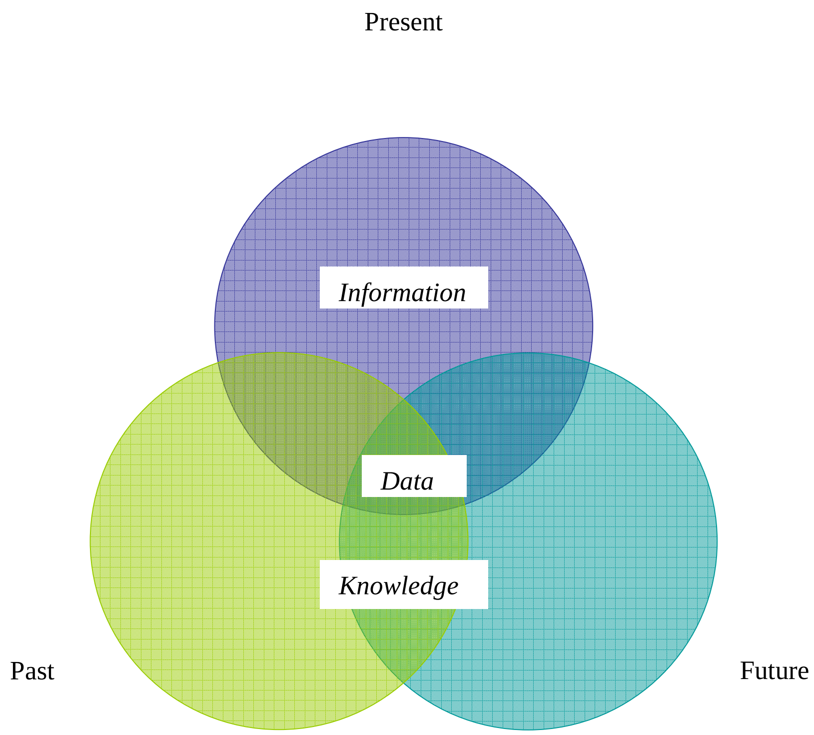


Figure 3: Temporal View of Learning (Venn diagram)

Time, knowledge acquisition and expertise

Learning has now been depicted within spatial and temporal dimensions, and in the context of knowledge acquisition in relation to time. This section considers knowledge acquisition and expertise and the temporal dimension. Dreyfus et al. (1986) classified levels of expertise into "five stages of skill acquisition": novice, advanced beginner, competent, proficient and expert. These five levels (stages) of human skill acquisition are summarised by Dreyfus et al. (1986). So, for example, at skill level four (proficient), the components are context-free (elements of a situation to be treated as relevant are so clearly and objectively defined that they can be recognised without reference to the overall situation in which they occur) and situational (attained through considerable experience in coping with real situations, "situational elements" are recognised by their perceived similarity with prior examples).

"The proficient performer, whilst intuitively organising and understanding [his] task, will still find [himself] thinking analytically about what to do. Elements that present themselves as important, thanks to the performer's experience, will be assessed and combined by rule to produce decisions about how best to manipulate the environment. The spell of involvement in the world of the skill will thus be temporarily broken" (Dreyfus et al., 1986: 29).

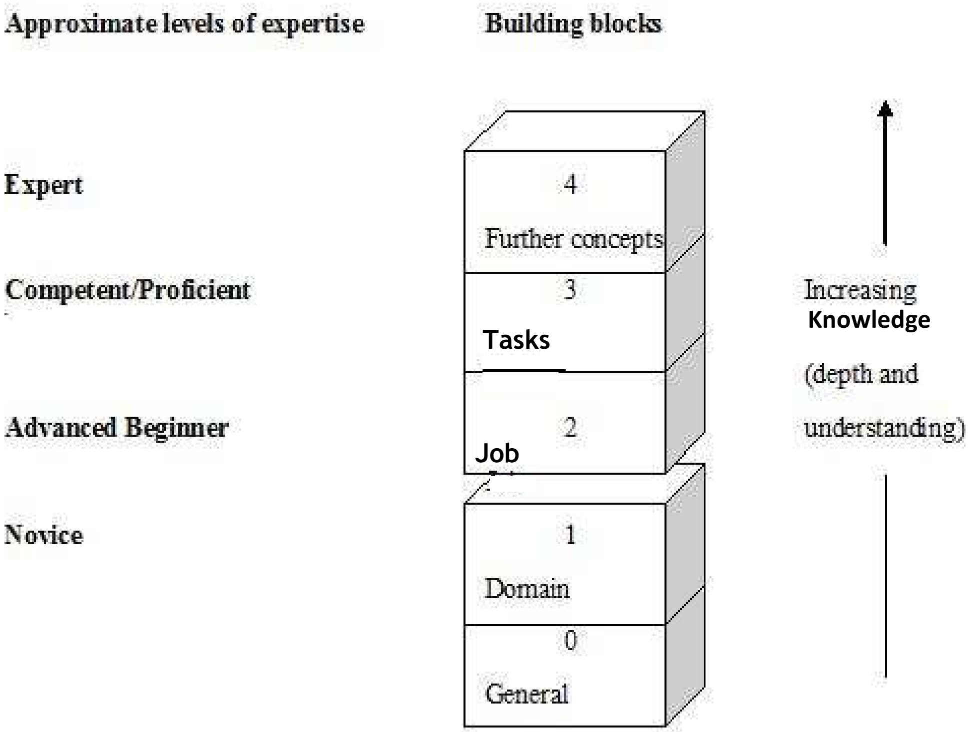


Figure 4: Knowledge Acquisition and Expertise: Building Blocks from Graham (1990), p.188

The relationship between levels of expertise and knowledge acquisition is described in Graham (1990):188-191] as shown in Figure 4. In terms of what is loosely referred to as "knowledge", there are five levels (0-4). Level 0 is the General level, which relates to general/world knowledge held by all humans. At the next level (level 1) Domain, background information about the domain is acquired by the Novice, for example, the organisation in which they are employed. Level 2 Job, situational data is acquired by the Advanced Beginner relevant to the job (overall task) of work. Level 3 Tasks, focuses on specific tasks involved in the job and requires some assimilation of experience, mostly through participant observation. This is where the levels of Competency and Proficiency are manifest. Increased experience may distinguish the Proficient from the Competent. The final level, Level 4 Further Concepts, is associated with the skill level of Expert, attained by the assimilation of corroborative quantitative data and qualitative information, and is strongly experientially based. The mapping of levels of expertise and knowledge acquisition was achieved through a case study in knowledge acquisition for the domain of computer hardware fault diagnosis and repair, involving the full spectrum of skill levels (from novice to expert) and vast amounts of data, information and knowledge acquisition.

The model in Figure 4 resulted from research into knowledge acquisition within the work place; however, Adams (2013) reported a complimentary model for knowledge acquisition/ skill attainment for students with visual impairments. The main commonality is the existence of knowledge layers and levels of skill. It is necessary to possess all the building blocks (lower skill levels) prior to those at the level you wish to reach. For example, the Domain (level 1) must be understood prior to understanding the Job (overall task, level 2). The more building blocks, the higher the skill level and the more substantial and complete the conceptual model. This order, the sequential attainment of skill levels and therefore learning, again signifies the importance of the temporal element.

Applying the model in Figure 4 to student learning: Level 0 (General) relates to general/ world knowledge (held by all humans). At Level 1 (Domain), background information about the domain is acquired by the Novice, in this case the organisation (university) in which they are students. In Level 2 (Job), situational data is acquired by the Advanced Beginner relevant to the "job" (overall task) of work, for instance, Study Skills and the University VLE. Level 3 (Tasks), focuses on specific tasks involved, such as the assessments themselves. Experience (practice) will discriminate between the Competent and the Proficient student. Level 4 (Further Concepts), likely to be associated more with post graduate students, particularly Doctoral students able to assimilate corroborative quantitative data and qualitative information, as it is strongly experientially based.

Discussion and Conclusions

The independent learner is likely to be at the skill level of Expert when it comes to learning, but education must cater for the majority of the non-expert learners. Early research on the development of the original Framework revolved around where learning occurs (the space) and therefore social interaction. The Transnational Cooperative Work Framework led to refocusing these concerns to those of where and when (space and time) understanding and learning take place.

Characteristics and dimensions of time in E-Learning processes refer mainly to the delivery mode. Information is informative only if it is timely. Learning requires the "metamorphosis" of data; from data to information and from information to knowledge. If the delivery is so delayed or out of sequence that it affects the context, it will have no meaning; only data/content will be provided by E-Learning systems. Current on-line systems are mainly data (base) or information (content management) systems oriented. It is somewhat ironic that original Computer Aided Learning (CAL) systems were knowledge-based, aiming to embody the expertise of domain experts. Contemporary systems focus on data retrieval, including semantic web technologies.

One of the oldest tutoring systems; GUIDON was developed from the expert or knowledge-based system MYCIN. MYCIN was designed for medical diagnostics at Stanford in the mid-1970s and was the forerunner for most knowledge-based systems, separating the domain expertise and knowledge (knowledge-base) from the mechanism (a forward or backward chaining inference engine).

"MYCIN provided clear and logical explanations of its reasoning, used a control structure appropriate to the specific problem domain, and identified criteria to reliably evaluate its performance" (Luger, 2002: 20-21).

These systems required the acquisition of knowledge and expertise, and were more akin to a human tutor as an expert in a specific domain. They were fact and rule based, applying propositional logic or predicate calculus to reach conclusions based on evidence (attributes of human experts). They enabled multiple conclusions with associated varying degrees of confidence (confidence factors), as well as "How" and "Why" queries. What is often presently provided by on-line systems are facts with little substance? Present systems contain many facts and information (content) but little knowledge or expertise is evident in spite of their superior multimedia and potential for multi-modal delivery; modern VLEs lack the knowledge-bases of early CAL.

Whilst recognizing that Expert Systems have difficulty in capturing "deep knowledge" and are not truly intelligent, such systems at least tried to encapsulate knowledge and expertise; modern VLEs focus more on intelligent search (state-space) with semantic information retrieval.

Normal human interaction involves cues (visual and audio), synchronicity, grounding, feedback and back-channels. The work in developing a cooperative work framework for E-Learning revealed that humans seem able to cope with the absence of visual or audio cues, or synchronicity, but the absence of all three could prove problematic. The School of the Air and Blended Learning do not have the problems of purely on-line (remote and asynchronous) delivery. Visual and audio cues provided by media streaming are also likely to be asynchronous, and video conferencing, although synchronous, can suffer problems (distortions) in transmission. "Just in time" may be a suitable approach to supply chain management, but not learning; it implies shallow and superficial learning which is not desirable for education per se or students.

Time, or rather the lack of synchronicity, has been shown to be a major problem. Unless synchronicity and responsibility issues are addressed, E-Learning will always remain an impoverished form of CMC because of the region of the Time/Space matrix it currently inhabits. Institutions can make simple improvements to ensure sequence (order) as a partial substitution for the lack of synchronicity. The argument for synchronicity or sequence is that they support context. Synchronicity aids the comprehension of communicated cues, feedback and back-channels and their interpretation, which supports context and grounding. Sequence is relevant to all learners in providing context and grounding and the building of skill levels; how can a student in Physics understand physics without the pre-requisite knowledge of basic mathematics? Sequence aids context, grounding and the building of skill levels; previous interactions impact on the meaning of those of the present and future.

One area where time (lack of synchronicity) in E-Learning could be exploited is for reflection, as new knowledge synthesis is suggested to take place at any point in time post the processing of information often for future predictions. The other area currently exploited is data retrieval, as data is temporally independent.

Either some synchronicity should be maintained or the temporal dimension must be more clearly embedded within VLEs. The Open University (OU) keeps lectures in a strict order/ sequence. The use of sequential delivery has an implicit temporal element, effectively another strand of information. Current tools still focus on content management and the spatial element. The OU example primarily for distance learning (spatial) is very pertinent. The OU has maintained the temporal strength/synchronicity by the use of its support tutors (providing remote but synchronous telephone communication) and summer schools (f2f communication); these also provide audio and visual cues.

The technologies widely available to better mediate E-Learning processes in relation to synchronicity are those of video conferencing, for example, the use of Skype, because they can be in real time. These tools, however, still present the problem of mindset – being able to work in such surreal environments is not natural or comfortable for everyone. It can be very disconcerting! The use of alternative tools such as video walls etc., are less available and perhaps even more disconcerting! The employment of such media raises its own problems, security and privacy etc.

It is suggested that most tutors aim to instill students to attain a level of Competence or Proficiency. Attaining Expertise requires more time to synthesise information and experience (more time as a practitioner), and this is beyond the remit of most undergraduate education via instruction only. Therefore, in terms of skill level, for students to achieve competence students must possess Levels 0-3 (Graham, 1990). Some students may become Proficient and encroach Level 4 through experience gained from a work placement for example (practice). In terms of knowledge acquisition; data, information and knowledge, students must be provided with data and some information which is achievable through VLEs, etc. The more difficult objective is the imparting of meta-knowledge by tutors or systems: How to "convert" data to information and information to knowledge. Expertise correlates with knowledge processing abilities; a novice acquires data, an expert analyses information to construct new knowledge structures, acquiring experience in order to make predictions. In terms of time; with age (time) comes experience. Experience equating to the "reinforcement" of neural synapses from short-term to long-term memory?

There is currently no VLE equivalent to a good tutor (expert), and, like information, the guidance given has to be contemporary. Current VLEs focus on the spatial elements of learning and search (information retrieval) of data and information. Perhaps there should be some refocusing towards knowledge and knowledge-based systems and time.

This paper has looked at the assessment and evaluation of time factors in on-line teaching and learning, by considering the relationship between levels of expertise (from novice to beginner to competent, proficient and expert), with both learning (the acquisition and synthesis of data to information and knowledge) and time, identifying the chronology of competence achievement. Cultural perceptions of time have not been addressed directly, however; in viewing E-Learning as CMC, cultural differences should be a part of the interaction design. The reason for not pursuing cultural perceptions in this paper is because there is too much for a satisfactory account to be given here, and such cultural perceptions extend beyond considerations of time. It is also acknowledged that most technologies, including learning systems, are designed from a predominately western cultural point of view, which raises many more questions.

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