e-Learning Artefacts: Are They Based on Learning Theory?

MR de Villiers

Abstract

With the advent of e-learning, educators and designers of learning resources should view technology as a tool and a medium, but not as the message. This paper poses the rhetorical question as to whether e-learning artefacts and variants are based on sound learning theory. It traces the evolution of e-learning and describes characteristics that indicate underlying theoretical biases in traditional educational software, as well as in online courses and web-based instruction. The paper introduces a synthesis of contemporary learning theory, the Hexa-C Metamodel (De Villiers, 2002, 2003), whose six elements can play a role in the design and development of e-learning environments and instructional systems, and which can also be used in evaluating educational applications from a learning theory perspective.

Keywords

e-Learning, design of instruction, educational technology, learning theory, interactive learning environments, web-based learning

1 Introduction

The role of technology in learning must be subservient to the envisaged learning outcomes. With the advent of e-learning, educators and designers of learning resources should view technology as a tool and a medium, but not as the message. This paper questions whether e-learning artefacts and environments are based on recognized learning theory. It describes various perspectives on e-learning and characteris-

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

tics that indicate an underlying theoretical bias, though artefacts may also be hybrids, with foundations emanating from various perspectives. Web-based instruction, in particular, can be characterized by its position in respect of various 'pedagogical dimensions' (Reeves and Reeves, 1997). The paper introduces a synthesis of contemporary learning theory, the Hexa-C Metamodel (De Villiers, 2002, 2003), whose six elements: cognitive learning, constructivism, components, creativity, customization, and collaborative learning, can play a role in the design and development of e-learning environments and instructional systems, and which can also be used in evaluating educational applications from a learning theory perspective.

Section 2 defines e-learning, while Section 3 reviews its development from the computer-aided instruction (CAI) systems of the 1960s to the present, dominated by the pervasive WWW and Internet. Roles and forms of e-learning in different domains are then overviewed and some underlying learning theories described in Section 4. In Section 5 the Hexa-C Metamodel is introduced and its relevance explained.

2 Definition of e-Learning

Some narrow definitions equate e-learning exclusively with the use of the Internet in instruction and learning. However, other definitions are broader. Clark and Mayer (2003:13) define e-learning as 'instruction delivered on a computer by way of CD-ROM, Internet, or Intranet, which ...

- Includes content relevant to the learning objective.
- Uses instructional methods such as examples and practice to help learning.
- Uses elements such as words and pictures to deliver content and methods.
- Builds new knowledge and skills linked to individual learning goals or to improve organisational performance'.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2007).

This view thus comprises both content (information) and instructional methods (techniques) to support the process of learning the content, but via a restricted range of hardware and media. The definition adopted by Cedefop (2002:5) is broader still, namely: 'learning that is supported by information and communication technologies (ICT). e-Learning is, therefore, not limited to ... the acquisition of IT competence but may encompass multiple formats and hybrid methodologies, in particular, the use of software, Internet, CD-ROM, online learning or any other electronic or interactive media'. This definition better suits the purposes of this paper, which takes an all-embracing approach, incorporating a broad range of educational technology and types of learning/instruction.

3 Evolution of e-Learning

In this section the advent and evolution of educational computing is overviewed as a background to Section 4, which surveys roles and forms of artefacts and their associated theoretical foundations.

e-Learning artefacts come, and have come, in many variants (Alessi and Trollip, 2001; O'Shea and Self, 1983; Jonassen, 1988), ranging from computer-based tutorials and drill-and-practice software through sophisticated intelligent tutoring systems to state-of-the-art interactive learning environments and problem-solving courseware, where learners use software as tools and not as tutors. One of the first platforms for CAI was PLATO, a project commenced by the University of Illinois in the 1960s and funded by the American National Science Foundation (NSF). PLATO ran on mainframe hardware and eventually enabled sophisticated multi-terminal interactive systems, which integrated text and graphics. It provided instructors with the first programming environment in which they could develop instructional courseware. CAI gravitated to minicomputers in the early 1970s with another NSF project, TICCIT (Time-shared, Interactive, Computer-Controlled Information Television project). It was aimed to be high performance and was based on factory-like production and pres-

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

entation of course materials. TICCIT also offered the concept of learner-control. However, due to the high costs incurred and the advent of microcomputers, such systems went into demise and the field of instructional computing suffered a setback, losing the benefits of networking (benefits that were only regained with the advent of the Internet).

In the late 1960s/early 1970s the artificial intelligence (AI) community came on the scene with intelligent tutoring systems (ITSs) or intelligent CAI (ICAI). Carbonell (1970) encapsulated these approaches with the term 'AI in CAI' as he described *Scholar*, a mixed-initiative tutor, which interactively presented concepts of geography, permitting both user and computer to share control of the dialogue and ask questions. Other ITSs had self-improvement facilities, whereby the ITS itself would learn by experience. ICAI did not move into the territory of general education, but tended to remain in academic research domains, largely because building intelligent software to simulate human tutors takes man-years of expert programming. During the 1980s and 1990s, conventional CAI in the form of tutorials and drill-and-practice software became popular, particularly in the USA and the UK. Such courseware was stand-alone, running off diskettes on micro- and desktop computers. Drill-and-practice software offers exercises in basic skills. The computer stores and randomly presents practice items to support specific instructional objectives. It provides record keeping and different levels of difficulty, often placing the learner on a level according to achievement in a pre-test. There may be an explicit 'game' ethos to extrinsically motivate performance. Tutorials are the classic instructional programs, using interactive dialogue to coach learners. Teaching segments are typically alternated with question segments, which respond with diagnostic feedback based on the learner's input. Unfortunately such systems have their origins in programmed instruction and operant conditioning, based on Skinnerian behaviourism and epitomized by the stimulus-response-reinforcement paradigm, an approach in which learners are largely treated as passive

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated)

recipients of information (Alessi and Trollip, 2001; O'Shea and Self, 1983).

In attempts to support more active learning, problem-solving software (Jonassen, 1988) originated, allowing learners to take active roles with the computer not as tutor, but as tutee or a tool. Other developments are open learning environments (Kok and Poorthuis, 1990), where students undertake limited exploration in defined task situations. The aim is to support them in independent acquisition of knowledge as they solve given problems. In another venture, physical classrooms are converted to collaborative electronic environments designed for active learning (Shneiderman *et al.*, 1998).

In this chronicle of e-learning, issues that have been noted – implicitly or explicitly – as sound features, include learner-control, networking, cost-effective production and dissemination, use of computing systems as tools instead of tutors, and the independence offered by active exploration rather than passive transfer. Some of these features occurred in certain systems, only to be sidelined in the next generation. Yet all of them are now incorporated and globally available within current technology, which has been transformed by the advent of the World Wide Web. The milieu of interactive educational computing has become an accessible resource at affordable prices in the form of portals, educational content websites, learning management systems, communication forums, etc. on the pervasive Internet.

In line with democratic paradigm shifts, the role of the learner is becoming more active, while the educator is viewed as less of an instructor and more of a facilitator.

4 e-Learning: Domains, Roles, and Underlying Learning Theories

This section outlines various perspectives on educational computing, considering, first, the type of domain from which the learning content is extracted and, second, the learning theories underlying e-

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

learning artefacts. Third, there is a categorization of the types of systems and the roles that technology can assume in the learning process and finally, the relationship between an artefact and its software construction process is addressed.

4.1 Type of Domain

In overviewing the underlying theoretical bias of e-learning artefacts, this paper first considers the type of domain from which the content to be taught or learned, originates. (Note the distinction between teaching, i.e. the role of the educator, and learning, i.e. the role of the student/pupil/learner.) There is a major difference between *well-structured* domains and *ill-structured* domains (De Villiers, 2003; Hannafin, Land and Oliver, 1999; Jonassen, 1999; Landa, 1998):

- Well-structured or closed domains contain concepts termed tightly defined, procedural or algorithmic, for example, syntactic, mathematical, scientific and computational subject matter, where rules and procedures are prescribed and problems solved by objective principles.
- Ill-structured or open domains contain problems with multiple solutions and alternative approaches, some aspects of which emerge only during the problem-solving process, for example, social sciences, management sciences, environmental disciplines and design disciplines. They require reflective practice (Schön, 1987) and heuristic, expert-type knowledge.

4.2 Theories of Learning and Cognition as Foundations of e-Learning

The functionality of e-learning applications is not conventional data processing as in commercial operations that process *business transactions*. Rather, e-learning entails supporting learners in the process of learning. It involves:

- Information transfer rather than information translation,
- Managing educational interaction,

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

- Supporting human cognition,
- Implementing behavioural change, and
- The leverage of technology as a medium and messenger, rather than as a message or showpiece in its own right.

In short, an *instructional transaction* entails the effective transfer or presentation of knowledge and skills, and unlike a business transaction, is not carried out by a professional doing his/her task in the workplace, but frequently by a novice, for whom the computer is a means of learning, not earning. It is therefore particularly important that the functionality of instructional systems is easy to learn and to use. Foundations for e-learning must be based on sound principles of learning theory and instructional design, in order to facilitate effective learning.

e-Learning applications reflect diverse views on cognition and learning, which are portrayed in Figure 1. The didactic approach views learning primarily as the acquisition by learners of knowledge structures and skills. This approach may tend to fixed transfer of information, and can be traced to the psychological school of *behaviourism* (Skinner, 1938). The associated instructional design models are somewhat rigid (Dick and Carey, 1996) and frequently program-controlled, although user-control and interactivity are on the increase. While behaviourism concentrates on shaping the learner's behaviour, the *cognitive* approach (elaborated in Section 5.1) emphasises the mental processes involved in learning. Greeno (1991) supports this classification, consolidating the roles of computing in education into *didactic* and *exploratory*. In the didactic approach, computers present information in a systematic individualized manner. The learning experience should be 'efficient' in terms of minimum errors on the part of the learner. Cognition is viewed as a mental system of information structures and procedures, and learning as the acquisition of these. The exploratory view treats learning less systematically, as the computer system presents phenomena that learners can investigate through interaction, discovering the transformations and constraints, e.g. Logo (Pa-

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

pert, 1988). This view fits a theory that considers cognition as situated in social and physical contexts.

At the extreme end of the spectrum is the *constructivist* ethos (Inhelder and Piaget, 1958; Bruner, 1994), which is elaborated in Section 5.2. This involves an open-ended, flexible, exploratory view, which situates learning contextually, encouraging learner-centricity and active learner-generation of products. Learning is scaffolded, rather than tutored.

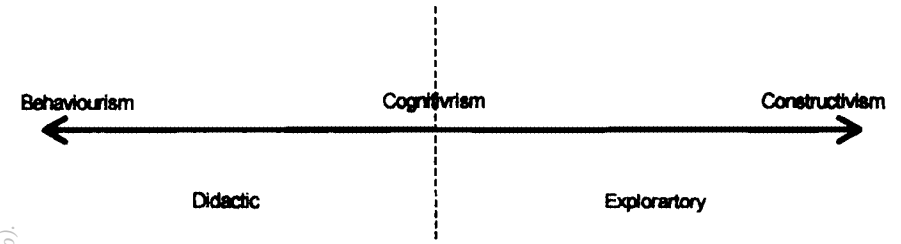

Figure 1: Spectrum of leaning theories

A further set of artefacts and weblications have no explicit theoretical foundation and are *pragmatically* constructed. This can occur, among others, in corporate vocational training, where designers may in fact, instinctively do 'the right thing', but may also produce systems with image appeal but superficial educational worth.

Explicit pedagogy should be integrated into learning resources. This is particularly important in online instruction and web learning environments (Firdyiwek, 1999; Winn, 1999), which are frequently used in distance learning, where misconceptions are harder to rectify.

Web-based instruction (WBI) and -learning (WBL) can be characterized by positions in respect of various 'pedagogical dimensions' (Reeves and Reeves, 1997). Based on research and theory in instructional technology, cognitive science and adult learning, Reeves and Reeves define ten dimensions of interactive learning that can be en-

Reproduced by Sabinet Gateway under licence granted by the publisher (dated 2010).

abled via the WWW, namely: (1) pedagogical philosophy, (2) learning theory, (3) goal orientation, (4) task orientation, (5) source of motivation, (6) role of the teacher, (7) metacognitive support, (8) collaborative learning, (9) cultural sensitivity, and (10) structural flexibility. Each of these can be represented in a simplified manner by considering it as a continuum between two extremes. Eight of the Reeves dimensions are particularly relevant to this paper: *Pedagogical philosophy* varies from strict instructivism to radical constructivism, where instructivism is based on the teaching of rigid structured objectives, viewing learners as passive recipients. *Learning theory* (as already stated) spans two dominant approaches in instructional design – the behavioural (based on the shaping of observable behaviours) and the cognitive (emphasizing internal mental states). *Task orientation* relates to the context of learning, whether it is abstract, such as a typical academic exercise, or authentic, e.g. training in a real-world activity. *Motivation* varies from extrinsic – the gold star, bells-and-whistles syndrome, to intrinsic motivation, where the learner's locus of control is integral to the learning. *Educators' roles* range between a didactic 'sage on the stage' and the facilitative, 'guide on the side'. *Metacognitive support* refers to the learner's own awareness of objectives, ability to plan and monitor one's own progress, access to resources or information, and the ability to adjust actions and reactions to accommodate requirements. The level of support can vary between unsupported and integrated. *Cultural sensitivity* is of paramount importance. Although it is unlikely that WBI can be adaptive to every cultural norm, websites should be respectful, avoiding insensitivity in terms of icons, symbols, graphics and terminology, so as to accommodate diverse ethnic and cultural backgrounds. Finally, there is *structural flexibility* with respect to the time and/or place of learning. This is related to the concept of the fixed instructional mode in a traditional academic setting as opposed to open education. One strength of WBI is its asynchronous nature, independent of place or time.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

Learning artefacts and events can be measured on continuums, according to these dimensions, and may well occupy central positions that show them to be hybrids.

4.3 Roles of Technology in Learning

Another perspective on technology in instruction and learning is based on the learner-content relationship as defined in Winn's (1992) *full* and *empty* instructional technologies. A full technology contains information to be transferred interactively to students, e.g. tutorials. An empty technology is a shell that supports exploration, communication, and construction, e.g. searches and generation of products using the Internet, and use by learners of commercial software as tools for manipulation, documentation, and generation of deliverables. A list follows of e-learning applications and approaches. Although a rigid categorization is impossible, since use varies according to the context and the users, this arrangement tends to be from the full to the empty.

- Direct instruction via online textbooks/workbooks;
- Drill and practice;
- CAI tutorials;
- Interactive television;
- Multi-media productions;
- Electronic classroom lectures;
- Simulations;
- Educational games;
- Interactive learning/practice environments;
- CD ROMs, dynamic Web-based resources, online courses;
- Open-ended learning environments and constructivist learning environments;
- Immersive virtual reality technology;

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

- Forums for educator-learner, learner-learner, and learner-external world communication:
  - Asynchronous examples: e-mail (which can be threaded), newsgroups, bulletin boards, listservs;
  - Synchronous examples: chat rooms, multi-user domains (MUDs), object-oriented MUDs (MOOs), video- or audio-conferencing; and
- Electronic portfolios of learners' work.

4.4 Relationship between an e-Learning Product and Its Construction Process

Another consideration relates not just to the *product*, but to its software development *process*. Trends in learning theory should be translated into reality in such a way that there is synergy between the underlying theoretical ethos, the development environment and the instructional strategies. There is a close relationship between the development paradigm and the resultant product (Winn, 1999).

For example, early procedural programming languages were process-oriented, describing steps with fixed algorithms. For educational applications this naturally generated systems that led learners through predetermined instructional sequences and activities, the nature of which was completely prescribed, yet which was appropriate for the predominantly behaviourist pedagogical ethos of the time.

Object-oriented programming and web-programming, on the other hand, require the developer to construct objects and operations that these objects should execute when specified events occur. Sequences are not prescribed and systems are open-ended. Such techniques radically alter the ways in which users act within those environments. They lend themselves to flexible interaction in rich multimedia environments, in harmony with cognitive and constructivist learning theory approaches. They are learner-centric in that students take the initia-

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

tive and the environment responds, and are thus well suited to inquiry-based and problem-based learning.

5 The Hexa-C Metamodel

Various factors impact on determining suitable theoretical foundations for a learning resource or artefact. No single paradigm is appropriate for all situations – domain, context and content all play roles. One particular approach may be relevant, or a hybrid approach. Technology should be matched to the pedagogical philosophy, as teaching/learning patterns are identified (Shneiderman *et al.*, 1998). The question arises as to whether some systems are based on theory at all. Are they are pragmatically constructed to suit the technology, ignoring theory or using an eclectic mix? Evaluation from the perspective of learning theory can be conducted in an attempt to answer this question for a particular application.

A six-sided approach, the Hexa-C Metamodel (HCMm) (De Villiers, 1999; 2002; 2003) integrates concepts from contemporary learning theory into a framework which serves as a design aid and for evaluating existing resources from the perspective of learning theory. It is termed 'Hexa-C' because each of its six inter-related elements commences with the letter 'C', and 'Metamodel', because it is a synthesis of existing theories, models, and paradigm. The HCMm incorporates several concepts addressed thus far in this paper and concisely suggests six elements to which the designer, educator or evaluator should pay cognizance, determining which are relevant to an intended or existing learning environment and, if relevant, to what extent and in what way the system should conform to those elements. Although the HCMm can be applied to any learning resource, the focus here is its relevance to e-learning and educational technology.

Three of the Cs: *constructivism*, *cognitive learning theory* and *components*, are primarily theoretical, while the others: *collaborative learning*, *creativity*, and *customization*, are practical means used by educators to foster effective and affective learning. Figure 2 shows the

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

hexagonal framework of the HCMm, representing its elements as merging segments around the hub of *technology*. This indicates technology's role as the mechanism that transfers the message, but not the message itself. The whole is embedded in *context*, emphasizing that the nature of each e-learning artefact or environment should be determined by its content and situation.

The HCMm has been used in evaluations of diverse learning systems, using triangulated data, both qualitative and quantitative (De Villiers, 2000; De Villiers and Cronje, 2001; De Villiers and Dersley, 2003).

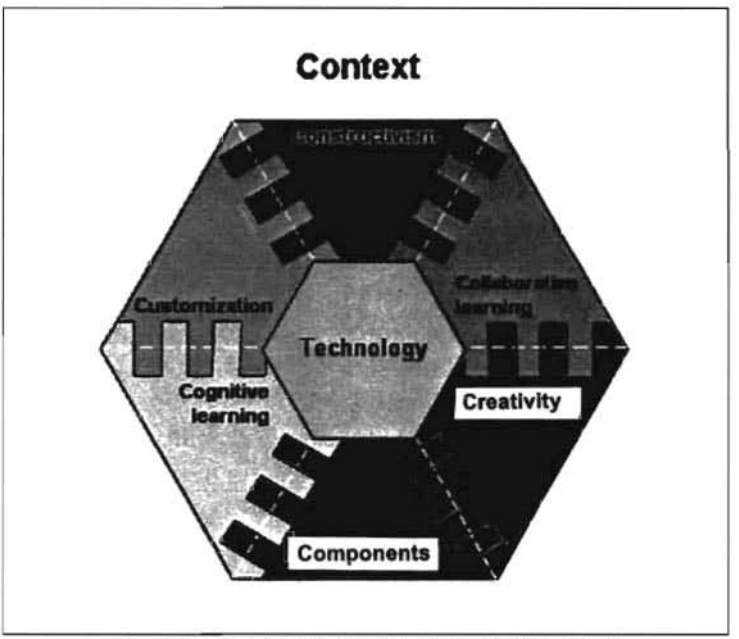

Figure 2: The framework of the Hexa-C Metamodel

The six HCMm elements are now introduced. It is not the intention that every resource or instructional system should conform to them all. The framework can support designers and practitioners in a

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

multi-faceted approach to effective and affective learning, but means of implementation vary. Each application, with its target learners and stage of learning, has a unique focus and is characterized by its educational content, problem-solving methods, and its physical/virtual situation. For example:

- Is the content domain well-structured or ill-structured?
- Is the instruction formal or informal; full-time or part-time; primary, secondary or tertiary education; market-related or workplace training?
- Is the context one of continuing education; distance-learning or contact-teaching; isolated or collaborative; based in a lab or at home?
- Are there formally graded outcomes?
- Does the application require a full or an empty technology?

5.1 Cognitive Learning Theory

Learning should support cognition, retention, and transfer. Cognitivism relates to the results of cognitive processes such as the formation of mental models, human information processing, metacognition, and self-regulation. New knowledge should be integrated with prior learning, building new skills on previous knowledge. Cognitive processes are seen as being as important as generating learning products. Cognitive learning aims to foster critical thinking skills by authentic problem solving or by explicit teaching of cognitive strategies alongside content knowledge (Anderson, 1983; Gagné and Merrill, 1990; Inhelder and Piaget, 1958; Minsky, 1975; Newell and Simon, 1972; Osman and Hannafin, 1992; Reigeluth, 1999; Reigeluth and Moore, 1999; West, Farmer and Wolff, 1991; Winn, 1990).

Even in closed domains, cognitive learning can be fostered. The traditional tutorial program can evolve beyond its behaviourist roots into a cognitive system. Although the tutorial process is systematically structured, with given information and predetermined relationships be-

Reproduced by School Gateway (digitally published 2010).

tween chunks of content, features such as high interactivity, animated process/object depiction and individualized diagnostic feedback, can support cognition. The relationship between theory and application may be addressed deductively – introducing concepts and rules before applying them, or inductively – moving from examples to underlying theory. Advanced 'challenge' activities should be provided for self-regulation and to stimulate higher-order thinking skills (HOTS).

5.2 Constructivism

Constructivism relates to personal knowledge construction and interpretation, active learning, anchored instruction, and multiple perspectives on an issue. Constructivist mechanisms include problem/project-based learning, open-ended learning environments, flexible learning within ill-structured domains, and authentic tasks – without simplification of complexity. Constructivism is not direct instruction; rather, it entails setting up learner-centric environments and activities, within which learners can explore and undertake discovery learning. Where possible, tasks should be authentic. The constructivist approach may use multiple modes of presentation (audio, visual, textual, interactive, etc.). It aims to instil personal goals and active involvement within real-world situated learning, leading to application skills and transfer. It emphasizes collaborative activities and learner-research using a wide variety of resources (Bruner, 1967; 1994; Cunningham, 1992; Duffy and Jonassen, 1991; Hannafin, 1992; Hannafin *et al.*, 1997; Jonassen 1994; 1999; Land and Greene, 2000; Lebow, 1993; Perkins, 1991; Savery and Duffy, 1995; Willis, 2000; Winn, 1992).

For project- and problem-based learning, software tools can be used directly by learners to search out information and to manipulate and present it using, for example, the WWW as an information resource, spreadsheets as cognitive tools to display findings and manipulate multiple parameters, and databases for storage and inquiry. (Information from the WWW should, however, be subjected to quality tests, checking its accuracy, authority, currency, uniqueness, links, and

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

writing quality (Smith, 1997).) In the design disciplines, graphics packages and animation can be used to convey information. Learners can develop multi-media products and create websites on which to post their work. Real-world activities enforce standards beyond the norm for academic efforts, demanding superior efforts and can result in constructivist frustration. In some cases, beyond academia, real-world projects become real-life products, usable in the workplace or the market.

5.3 Components

Components within learning and instruction (Reigeluth, 1999) relate to the basic knowledge, skills and methods of a domain. One approach is component display theory (CDT) (Merrill, 1983), based on relationships between the kind of content taught (fact, concept, procedure, and principle) and the level of performance required (remember, use, or find). CDT examines whether the instructional strategies used in a learning event achieve its instructional goals. Each learning objective is related to the appropriate content and desired performance, resulting in an instructional component that is positioned in a performance-content matrix.

Componential instruction is more relevant in well-structured domains, where explicit teaching is needed of the basic knowledge and skills, often in decontextualized settings. Unitary components can be integrated to form composite components (De Villiers, 2002). Merrill (2001) emphasizes the role of instructional components as theoretical tools to facilitate the design of effective, efficient and appealing instructional products, both in directive tutorials and in environments for experiential learning. In the latter, knowledge of the basics should be assumed, but linked access can be provided to subject matter resources.

5.4 Creativity and Motivation

Creativity supports the affective aspects of instruction, aiming for novelty within functionality in ways that motivate learners intrinsically

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

(Caropreso and Couch 1996; De Bono, 1970; Dick 1995; Jones, 1998; Malone, 1981). Creative instruction aims to incorporate affective aspects within learning, seeking to apply innovative instructional strategies, to engage learners, and to strengthen the affective-cognitive bond (Price, 1998; Wager, 1998), whereby values and emotions influence learners' initial ability to acquire knowledge (external affective aspects) and their ongoing attitude and perseverance (internal affective aspects).

Creativity is closely connected to intrinsic motivation and engagement of learners. Application of the ARCS model (Keller and Suzuki, 1988) suggests that instruction should: gain attention, ensure relevance, instil confidence, and lead to learner-satisfaction. Creativity is rewarded when learners experience 'flow' (Csikszentmihalyi, 1990), forgetting time and tackling more than envisaged!

Creativity can be in evidence, first, in the learning environment and second, in the activities or product development undertaken by learners. Novel, innovative environments and presentations help to engross learners, provided that such means or themes are inherently part of the learning experience and not creeping featurism (Norman, 1998) or distractive 'bells-and-whistles'. Multimedia can support creativity, also serving as multi-gate reinforcement. Open learning systems, such as web-based 'virtual classrooms', have scope for informality and humour, particularly in learner-learner contact on discussion forums. HCMm research has shown that creativity fosters creativity, as novel instructional situations stimulate learners, in turn, to De Bono's (1970) lateral thinking.

5.5 Customization

The movement towards customizing/individualizing learning (Alessi and Trollip, 2001; Bruner, 1967; Norman and Spohrer, 1996; Reigeluth, 1999) aims for learner-centric instruction that adapts to individual profiles, supports personal processes and products, and allows learners to take initiative regarding (some of) the methods, time, place,

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

content, and sequence of learning. It supports learner-control, negotiated goals, and the ethos of matching learners' needs and interests.

Classic CAI incorporated program-controlled 'branching', navigating learners through material according to their performance. Learner-controlled customization, by contrast, allows learners some say regarding time and place of learning, tasks, modes and media, levels of difficulty, and degree of help.

True learner-centricity is enabled in unstructured domains where learners tackle open-ended projects. Auto-customization and customization by content occur as learners:

- Choose their own approach within set content, using tools and techniques in ways that are personally optimal;
- Determine own content and direction within a broad domain, developing own product; or
- Customize learning by choosing between options when they do tasks/assignments and by taking specialized roles within teams.

In problem-based contexts, learners should direct the learning, conduct independent research, collect, analyse and manipulate information, draw conclusions and present findings.

5.6 Collaborative Learning

Collaborative learning involves joint work, social negotiation, a team approach, accountability, and peer evaluation, i.e. sharing of responsibility within a group. It optimizes on complementarity and instils collaborative skills in learners (Johnson and Johnson, 1991; Nelson, 1999; Panitz, 1996; Singhanayok and Hooper, 1998). Collaboration is closely associated with constructivism and open learning, and is applied in project-based and problem-based learning.

Collaborative learning is not usually considered suitable for algorithmic tasks with tightly defined procedures, yet experience shows spontaneous joint use, two-at-a-computer, interacting with artefacts intended for individual use. Co-operative problem solving and peer-

Reproduced by Sabinet Gateway under licensing agreement with Publisher (dated 2010).

teaching can be effective means of learning and confidence building. In less structured tasks and projects, role allocation should capitalize on skills and strengths and support weaknesses, providing an efficient approach where complex knowledge and varied expertise are required. It is excellent preparation for the real world and the workplace. A further form of collaborative participation is electronic voting within a physical or virtual classroom.

5.7 Application and Relevance of the C-Elements

The HCMm and its constituent elements have been introduced. Can these elements be converted directly into principles that set out underlying theoretical foundations for the phenomenon of e-learning? No, not directly, but in adapted contextualized forms, yes. For example, sets of evaluation criteria/questions have been compiled and applied in specific survey evaluations and in heuristic evaluations (De Villiers, 2000; De Villiers and Cronje, 2001; De Villiers and Dersley, 2003). However, no single set of design guidelines or evaluation criteria would be generally applicable since artefacts differ in terms of underlying domain, subject matter, situation of use, and the purpose – to teach, tutor, be a tutee or toolset, or to serve as an exploration environment.

It is up to the educator or designer of e-learning to take the HCMm as a conceptual framework and translate its elements into principles, design guidelines, and evaluation criteria appropriate for the specific requirements. Evaluations may be conducted on existing applications to determine whether they are grounded in learning theory. More important, for designers and would-be designers, there is the opportunity to construct new systems and environment that are constructed on a foundation of learning theory, either with a purist ethos or by combining various theoretical stances which are coherent and consistent with each other.

At the risk of simplification, and while acknowledging exceptions, the matrix in Figure 3 lists forms of e-learning against the C-elements,

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

marking with an **x** those appropriate for consideration in the design of a particular artefact or system. The large **X**s indicate stronger relationships.

	Components	Cognitive learning	Constructivism	Customization	Collaborative learning	Creativity
Online books	X	x		x		x
Interactive television	X	X		x		x
Drill and practice	X			X		
Tutorials	X	X	x	X	x	X
Multimedia productions	x	x	x		x	X
Electronic class lectures	X	x			x	x
Simulations		x	X	X	x	x
Educational games	x		X	X	X	x
Interactive and open learning environments			X	X	X	X
CD ROMs	x	x	x	x	x	x
Online courses	X	x	x	X	x	x
Dynamic WBI	x		X	X	x	X
Virtual reality			x	x		X
Asynchronous communication forums: email, newsgroups, etc		x	x	X	X	
Synchronous communication forums: chat rooms, etc		x	x	x	X	
Electronic portfolios			X	X		X
Video / audio conferencing				X	X	

Figure 3 Relationship between HCMm elements and types of e-learning

6 Conclusion

This paper overviews the concept and evolution of e-learning and investigates the theoretical foundations of educational artefacts. The HCMm is presented as a conceptual framework which integrates tenets of contemporary learning theory. The design and implementation of a variety of e-learning systems can be enhanced by considering these

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010)

elements and explicitly applying those appropriate to the domain. No single paradigm is appropriate for all situations, but its elements can be translated into principles, design guidelines, and evaluation criteria customized for specific domains, subject matter and contexts. The instructional designer, e-learning practitioner or educational web developer should ensure that technology serves as the hub which transfers the message and in no way detracts or distract from the message. Finally, the question posed in the title of this article, namely whether e-Learning artefacts are based on learning theory, can be answered in the affirmative.

References

Alessi, SM & SR Trollip 2001. *Multimedia for Learning: Methods and Development*. Englewood Cliffs, N.J.: Prentice Hall.

Anderson, JR 1983. *The Architecture of Cognition*. Cambridge MA: Harvard University Press.

Bruner, JS 1967. *Toward a Theory of Instruction*. Cambridge Mass: Harvard University Press.

Bruner, J 1994. Constructivist Theory.
http://tip.psychology.org/bruner.html

Carbonell, J.R. 1970. AI in CAI: An Artificial Intelligence Approach to Computer-Assisted Instruction. *IEEE Transactions on Man-Machine Studies* 11: 190-202.

Caropreso, EJ & RA Couch 1996. Creativity and Innovation in Instructional Design and Development: The Individual in the Workplace. *Educational Technology* 36(6):31-39.

Cedefop (European Centre for the Development of Vocational Training) 2002. *E-learning and training in Europe*. Luxenbourg: Office for Official Publications of the European Communities.

Clark, RC & RE Mayer, 2003. *E-Learning and the Science of Instruction*. San Francisco: Pfeiffer.

Csikszentmihalyi, M 1990. *Flow: the Psychology of Optimal Experience*. New York: Harper and Row.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

Cunningham, DJ 1992. Assessing Constructions and Constructing Assessments: A Dialogue. In TM Duffy & DH Jonassen (Eds.) *Constructivism and the Technology of Instruction: A Conversation.* Hillsdale, N.J.: Lawrence Erlbaum Associates.

De Bono, E 1970. *Lateral Thinking: A Textbook of Creativity.* Harmondsworth: Penguin Books.

De Villiers, MR 1999. Applying the Hexa-C Metamodel of Instructional Theory and Design to Educational Web Applications. In P De Bra & J Leggett (Eds.) *Proceedings of Web Net 99 – World Conference on the WWW and Internet.* Honolulu: Association for the Advancement of Computing in Education.

De Villiers, MR 2000. Evaluation of an Interactive Learning Environment: Theory and Practice. *South African Journal of Higher Education* 14(3):120-131.

De Villiers, MR 2002. *The Dynamics of Theory and Practice in Instructional Systems Design.* Unpublished PhD dissertation. Pretoria: University of Pretoria.

De Villiers, MR 2003. Foundation for Structure: A Learning Theory Approach to Instructional Design for e-Learning. *International Journal of Learning Vol 10 2003/04.* Proceedings of the Learning Conference 2003. Australia: Common Ground Publishing. .

De Villiers, MR & JC Cronjé 2001. Co-Operative Learning in an Immersed Internet-Based Virtual Learning Community. *Proceedings of Web Net 2001– World Conference on the WWW and Internet.* Orlando, USA.

De Villiers, MR & R Dersley 2003. Emerging Technology for Emerging Peoples: Evaluation of an African AIDS-Awareness Training System. *Proceedings of Ed-Media 2003 World Conference on Educational Hypermedia and Telecommunications.* Honolulu, USA.

Dick, W 1995. Instructional Design and Creativity: A Response to the Critics. *Educational Technology* 35(4):5-11.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

Dick, W & L Carey 1996. *The Systematic Design of Instruction* (4th Edition). New York: Longman.

Duffy, TM & DH Jonassen, 1991. Constructivism: New Implications for Instructional Technology? *Educational Technology* 31(5):7-12.

Firdyiwek, Y 1999. Web-Based Courseware Tools: Where Is The Pedagogy? *Educational Technology* 39(1):29-34.

Gagné, RM & MD Merrill 1990. Integrative Goals for Instructional Design. *Educational Technology Research and Development* 38(1):23-30.

Greeno, JG 1991. Productive Learning Environments. In R Lewis, & S Otsuki (Eds) *Advanced Research on Computers in Education.* North Holland: Elsevier Science Publishers.

Hannafin, MJ 1992. Emerging Technologies, ISD, and Learning Environments: Critical Perspectives. *Educational Technology Research and Development* 40(1):49-63.

Hannafin, MJ, KM Hannafin, SM Land & K Oliver 1997. Grounded Practice and the Design of Constructivist Learning Environments. *Educational Technology Research and Development* 45(3):101-117.

Hannafin, M, S Land & K Oliver 1999. Open Learning Environments: Foundations, Methods, and Models. In CM Reigeluth (Ed.) *Instructional-Design Theories and Models Volume II: A new paradigm of instructional theory.* Mahwah, N.J.: Lawrence Erlbaum Associates.

Inhelder, B & J Piaget, 1958. *The Growth of Logical Thinking from Childhood to Adolescence.* New York: Basic Books Inc. Publishers.

Johnson, DW & RT Johnson, 1991. *Learning Together and Alone.* Englewood Cliffs, NJ: Prentice Hall.

Jonassen, DH 1988 (Ed.) *Instructional Designs for Microcomputer Courseware.* Hillsdale. NJ: Lawrence Erlbaum Associates.

Jonassen, DH 1994. Thinking Technology: Towards a Constructivist Design Model. *Educational Technology* 34(4):34-37.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

Jonassen, D 1999. Designing constructivist Learning Environments. In CM Reigeluth (Ed.) *Instructional-Design Theories and Models Volume II: A New Paradigm of Instructional Theory*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Jones, MG 1998. *Creating Engagement in Computer-Based Learning Environments*. ITForum Paper #30. http://it.coe.uga.edu/itforum/paper30/paper30.html

Keller, JM & K Suzuki, 1988. Use of the ARCS Motivational Model in Courseware Design. In DH Jonassen (Ed.): *Instructional Designs for Microcomputer Courseware*. New Jersey: Lawrence Erlbaum Associates.

Kok, W & G Poorthuis 1990. The Effects of Different Teaching Strategies in Three Cai Programs within the Same Content Area. In JM, Pieters, PRJ Simons & L De Leeuw (Eds.): *Research on Computer-Based Instruction*. Amsterdam: Swets and Zeitlinger.

Land, SM & BA Greene 2000. Project-Based Learning with the World Wide Web: A Qualitative Study of Resource Integration. *Educational Technology Research and Development* 48(1):45-68.

Landa, LN 1998. Methodological Drawbacks of Current Educational Software and Suggestions for Radical Improvement Based on Algo-Heuristic Theory. *Educational Technology* 38(5):54-56.

Lebow, D 1993. Constructivist Values for Instructional Systems Design: Five Principles Toward a New Mindset. *Educational Technology Research and Development* 41(3):4-16.

Malone, TW. 1981. Toward a Theory of Intrinsically Motivating Instruction. *Cognitive Science* 4:333-369.

Merrill, M.D 1983. Component Display Theory. In CM Reigeluth, (Ed.) *Instructional Design Theories and Models: An Overview of Their Current Status*. Hillsdale, N.J: Lawrence Erlbaum Associates.

Merrill, MD 2001. Components of Instruction toward a Theoretical Tool for Instructional Design. *Instructional Science* 29: 291-310.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2007).

Minsky, ML 1975. A framework for Representing Knowledge. In PH Winston, (Ed.) *The Psychology of Computer Vision*. New York: McGraw-Hill.

Nelson, LM 1999. Collaborative Problem Solving. In CM Reigeluth (Ed.) *Instructional-Design Theories and Models Volume ii: A New Paradigm of Instructional Theory*. Mahwah, N.J: Lawrence Erlbaum Associates.

Newell, A & HA Simon, 1972. *Human Problem Solving*. Englewood Cliffs, N.J: Prentice-Hall Inc.

Norman, DA 1998. *The Design of Everyday Things*. London: MIT Press.

Norman, DA & JC Spohrer, 1996. *Learner-Centered Education*. IT-Forum Paper #12.
http://it.coe.uga.edu/itforum/paper12/paper12.html

O'Shea, T, & J Self 1983. *Learning and Teaching with Computers*. Brighton: The Harvester Press.

Osman, ME & MJ Hannafin 1992. Metacognition Research and Theory: Analysis and Implications for Instructional Design. *Educational Technology Research and Development* 40(2):83-99.

Panitz, T 1996. *A Definition of Collaborative Versus Cooperative Learning*.
http://www.lgu.ac.uk/deliberations/collab.learning/panitz2.html

Papert, S 1980. *Mindstorms: Children, Computers and Powerful Ideas*. New York: Basic Books.

Perkins, DN 1991. What Constructivism Demands of The Learner. *Educational Technology* 31(9):19-21.

Price, EA 1998. Instructional Systems Design and the Affective Domain. *Educational Technology* 38(6):17-28.

Reeves, TC & PM Reeves, 1997. Effective Dimensions of Interactive Learning on the World Wide Web. In BH Khan (Ed.): *Web-Based Instruction*. Englewood Cliffs, N.J New Jersey: Educational Technology Publications.

Reigeluth, CM 1999. What Is Instructional-Design Theory and How Is It Changing? In CM Reigeluth, (Ed.): *Instructional-Design*

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

Theories and Models Volume II: A New Paradigm Of Instructional Theory. Mahwah, N.J: Lawrence Erlbaum Associates.

Reigeluth, CM & J Moore, 1999. Cognitive Education and the Cognitive Domain. In CM Reigeluth, (Ed.): *Instructional-Design Theories and Models Volume II: A New Paradigm of Instructional Theory.* Mahwah, N.J: Lawrence Erlbaum Associates.

Savery, JR & TM Duffy, 1995. Problem Based Learning: An Instructional Model and Its Constructivist Framework. *Educational Technology* 35(5):31-38.

Schön, D 1987. *Educating the reflective practitioner.* San Francisco: Jossey-Bass Publishers.

Shneiderman, B, EY Borkowski, M Alavi, & K.Norman 1998. Emergent Patterns of Teaching/Learning in Electronic Classrooms. *Educational Technology Research and Development* 46 (4): 23-42.

Singhanayok, C & S Hooper 1998. The Effects of Cooperative Learning and Learner Control on Students' Achievement, Option Selections, and Attitudes. *Educational Technology Research and Development* 46(2):17-33.

Skinner, BF 1938. *The Behaviour of Organisms: An Experimental Analysis.* New York: Longman.

Smith, AG 1997. Testing the Surf: Criteria for Evaluating Internet Information Resources. *The Public-Access Computer Systems Review* 8(3).
http://info.lib.uh.edu/pr/v8/n3/smit8n3.html

Squires, D 1999. Educational software for Constructivist Learning Environments: Subversive Use and Volatile Design. *Educational Technology* 39(3):48-53.

Wager, W 1998. Social determinants of Affective Behavior and Learning. *Educational Technology* 38(6):15-16.

West, CK, JA Farmer & PM Wolff 1991. *Instructional Design: Implications from Cognitive Science.* Englewood Cliffs, N.J.: Prentice Hall.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

Willis, J 2000. The Maturing of Constructivist Instructional Design: Some Basic Principles that Can Guide Practice. *Educational Technology* 40(1):5-16.

Winn, W 1990. Some implications of Cognitive Theory for Instructional Design. *Instructional Science* 19(1):53-69.

Winn, W 1992. The Assumptions of Constructivism and Instructional Design. In TM Duffy & DH Jonassen (Eds.): *Constructivism and the Technology of Instruction: A Conversation.* New Jersey: Lawrence Erlbaum Associates.

Winn, W 1999. Learning in Virtual Environments: A Theoretical Framework and Considerations for Design. *Educational Media International* 36(4): 271-279.

Author's Contact Details

M R de Villiers (DVILLMR@unisa.ac.za)
School of Computing
University of South Africa, Pretoria, South Africa

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).