A learning theory approach in support of outcomes-based e-learning

M.R. (Ruth) de Villiers
University of South Africa
dvillmr@unisa.ac.za

ABSTRACT

Outcomes-based education (OBE) is the educational paradigm currently advocated in South Africa. This paper proposes the Hexa-C Metamodel (HCMm) as a learning theory foundation for the design and development of e-learning applications to support OBE where appropriate. The HCMm integrates six concepts from contemporary learning theory into a framework that serves as a design and evaluation aid for e-learning. The National Department of Education views OBE as an approach that can build a culture of meaningful learning for a heterogeneous body of learners. The seven critical outcomes of OBE can be supported by the ethos and elements of the HCMm. Each outcome is discussed in turn, suggesting how various HCMm elements can be used in e-learning to help learners attain that outcome in the context of tertiary education.

Key words

Cognitive learning, collaborative learning, constructivism, creativity, customization, e-learning, e-learning design, higher education, learning theory, outcomes-based education

INTRODUCTION

This paper proposes the *Hexa-C Metamodel (HCMm)* as a learning theory foundation for the design and development of *e-learning* applications to support the *outcomes-based education (OBE)* approach advocated in South Africa. The idea is not to participate in policy debate or to discuss the merits of OBE, but simply to outline tenets of current learning theory and to suggest strategies and learning activities that are in line both with the ethos of the HCMm and with OBE. The approaches suggested are generic and decontexualized. Specific instantiation is up to e-learning designers and multimedia developers, who can contextualize these ideas and apply them to their particular environments and curricula.

E-LEARNING

The term *e-learning* commonly refers to teaching and learning delivered by the Internet and World Wide Web or on an intranet (Catherall, 2005; Erskine, 2003). However, some definitions (CEDEFOP, 2002; Clark & Mayer, 2005; Wesson & Cowley, 2003) are broader, including further formats and methodologies, such as multimedia CD-ROM, educational software and traditional computer-aided learning (CAL). Examples of e-learning (De Villiers, 2005) are online courseware, tutorials, interactive learning environments, multi-media applications, simulations, hyperlinked 'textbooks', web-based instruction, and use of the Internet. Furthermore, this paper takes the stance that use by learners of computers-as-tools is also a form of e-learning. Over and above instructional and learning-support functionality, some e-learning systems have administrative facilities such as course management and recording of progress, but this paper relates to learning functionality only.

E-learning can contribute to the implementation of OBE. This paper proposes a learning-theory foundation for the development of interactive e-learning activities and web-based learning to support OBE as advocated in South Africa and the attainment of its seven critical outcomes.

OUTCOMES-BASED EDUCATION (OBE)

The Outcomes

The National Department of Education (DOE) advocates OBE as a means of building a culture of meaningful learning within a heterogeneous body of learners with a historic dichotomy, regardless of the domain or content of learning. It is founded on seven *critical outcomes* (South Africa, 1998), of which Outcomes 1, 2 and 5 are *underlying* outcomes that help to render other performances possible. The seven outcomes required of South African learners are as follows:

1. *Problem-solving skills:* Identifying and solving problems in which responses show that responsible decisions have been made, using critical and creative thinking.
2. *Teamwork:* Working effectively with others in a team or group.
3. *Self-responsibility skills:* Organizing and managing oneself and one's activities responsibly and effectively.
4. *Research skills:* Collecting, analyzing, organizing and critically evaluating information.
5. *Communication skills:* Communicating effectively in oral or written mode, using language or visual skills or notational means (e.g. mathematical/scientific notations).
6. *Technological and environmental literacy:* Using science and technology effectively and critically, showing responsibility towards the environment and the well-being of others.
7. *Developing macrovision:* Demonstrating an understanding of the world as a set of related systems, recognizing that problem-solving contexts do not exist in isolation.

There are also five *developmental* outcomes, according to which it is envisaged that learners should ultimately be able to:

8. Reflect on and explore various strategies in order to learn more effectively.
9. Participate as responsible citizens in local, national and global communities.
10. Be culturally and aesthetically sensitive across a range of social contexts.
11. Explore education and career opportunities.
12. Develop entrepreneurial opportunities.

Principles of OBE

The OBE approach (Killen, 2000) addresses the outcomes of education with a view to evaluating investments in education, i.e. there are political and economic, as well as educational, motivations for OBE. The OBE philosophy embodies a particular set of beliefs about learning and its associated activities. Spady (1994) promotes an educational system structured around what is essential for all learners to be able to do successfully at the end of a learning experience. The approach is thus focused on the desired results of education, expressed in terms of outcomes. It is also important that the outcomes reflect the complexities of the real world and are relevant to life-roles that learners face after their education. Fundamental OBE principles in the context of formal school education are as follows (Killen 2000; Spady, 1994):

1. Clarity of focus: educators should explicitly determine what it is they require learners to do successfully and the process should correspondingly be geared towards appropriate knowledge, but particularly skills and dispositions. Assessment is focused on the same significant outcomes, i.e. there should be congruency between outcomes and assessment.
2. Designing back: Curriculum design starts by defining the desirable end results and working backwards to identify the building blocks that learners must achieve to reach the end-outcomes, i.e. decisions should be taken and systematic frameworks compiled with a view to supporting learners in attaining the defined significant outcomes.
3. High expectations: With the belief that OBE can help all learners to do difficult things well, the idea is that educators should establish challenging standards of performance and encourage learners to engage deeply with the learning issues.
4. Expanded opportunities: Educators must provide expanded opportunities for all learners. The idea is not that things should be learned in a particular way or at a stated time, but that learners should learn that which is important and be given appropriate opportunities to do so. Although this approach has practical difficulties, it should be viewed against the longer-term benefits of enabling all learners to be successful (Killen, 2000).

What does OBE in tertiary education entail? The baselines in OBE are set by the required 'exit outcomes of significance, with culminating demonstrations of learning' (Kilfoil, 1999:9), where an outcome is what students are successfully able to do in particular situations, and not their content knowledge. As explained, outcomes can be 'designed back', reverse-engineered into defined performances. Furthermore, outcomes are not the same as objectives. An objective relates to what a learner should know, whereas an outcome is a demonstration, in a stated context, of a significant performance by the learner, for example, s/he shows how s/he can solve a particular problem. In general, university educators should first investigate their disciplines so as to determine the stipulated outcomes expected of learners and then consider what additional real-life performances could be expected from university graduates (Kilfoil, 1999). Goodwin-Davey (2000) proposes that learning cannot be placed at the centre of education unless the curriculum is focused on outcomes, and that knowledge by educators of what the intended outcomes are, is essential for quality assurance.

Under OBE the educator is less an instructor, and more a facilitator or a mentor.

Problems within OBE

The OBE approach brings problems with it, notably in the higher education sector. After decades of academic freedom, universities are being required to come into line with OBE, leading to concerns that external priorities might conflict with the traditional goals, visions and missions of the tertiary sector. However, curricula are not being imposed, as occurs within the formal primary and secondary education sectors; instead universities undertake their own research and academic discussions on how to implement OBE. Nonetheless there are legitimate concerns, such as the suspicions of the Australian and New Zealand higher education sectors that OBE is reductionist and behaviourist and, as such, not in line with the goals and ethos of a university. Universities are proponents of the intrinsic worth of knowledge itself and are less concerned with instrumental ends (Kilfoil, 1999).

In the secondary education context, Venter (2000) expresses concern regarding assessment. OBE de-emphasizes traditional assessment and grading, advocating criterion-based assessment instead of a competitive norm-based approach. Under OBE, skills and processes are assessed, rather than knowledge assessment. This focus on learner activities is not necessarily conducive to the coherent development of concepts, which is ironical in the light of Outcome 7, which requires an understanding of the world as a set of related systems, acknowledging that problem-solving contexts do not exist in isolation.

The present author believes that the HCMm can contribute to the educational situation in South Africa, due to its compatibility with aspects of outcomes-based education, as proposed by the DOE (South Africa, 1998; South African Qualifications Authority, 2001). OBE is intended to build a culture of meaningful learning, regardless of the domain or content of learning. The ethos and elements of the HCMm have a relationship to the seven critical educational outcomes. All except the seventh outcome are implicitly or explicitly incorporated within the framework shown in Figure 2 and discussed in the next section, which describes the HCMm. The seventh outcome could be achieved as a consequence of the experiential and holistic thinking entailed in knowledge construction. The subsequent (main) section of the paper deals with the relevance of the HCMm to OBE by suggesting generic strategies that apply elements of the HCMm to support OBE outcomes.

THE HEXA-C METAMODEL (HCMm)

The Hexa-C Metamodel (HCMm) is a compact and concise approach, which integrates concepts from contemporary learning theory into a framework that serves as a design and evaluation aid for e-learning systems, such as educational software, online learning, and WBL. It is termed 'Hexa-C' since each of its six elements starts with 'C' and 'Metamodel' because it synthesizes existing models (De Villiers, 2005). Discerning use of its elements can support the design of effective and appealing instructional products, textual course material, conventional learning activities and e-learning. In the last case it can be applied both in computer-based courseware and in online environments for experiential learning and communication. As shown in Figure 1, the HCMm is proposed as a learning theory platform for the development of e-learning applications that support electronic aspects and activities within outcomes-based education.

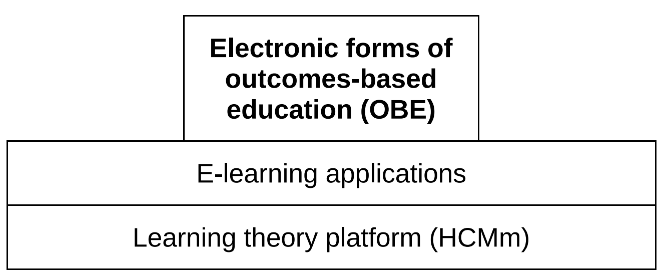

Figure 1. Relationship of the HCMm to electronic OBE

Figure 2 shows the HCMm, representing its inter-related *elements* as merging segments. E-learning content and methods differ in every situation, so the framework is embedded in *context*. The hub is *technology*, which is the medium but not the message; the transfer tool but not the teacher. Descriptions follow of the six elements:

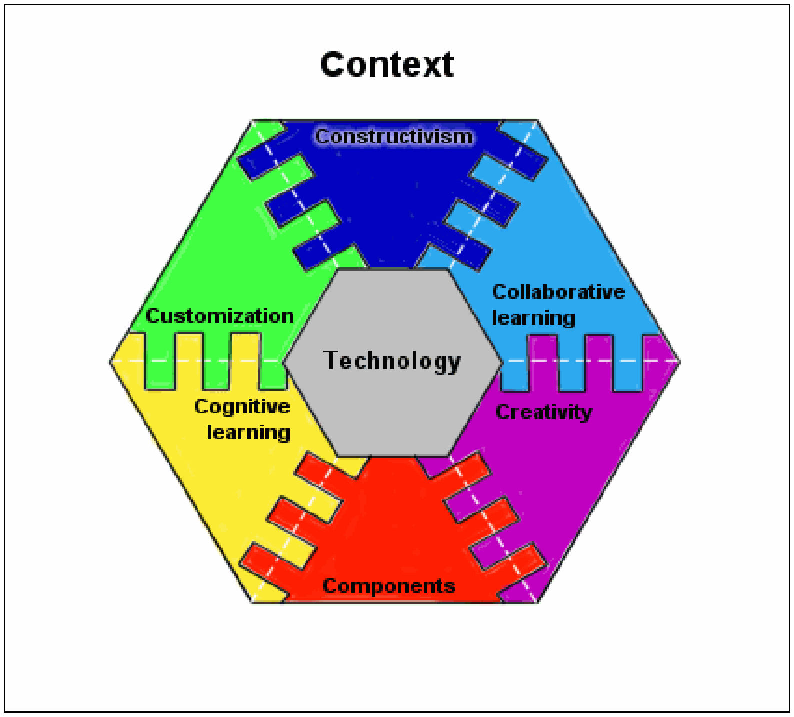

Figure 2. The framework of the Hexa-C Metamodel

Cognitive learning

The element of cognitive learning within e-learning highlights aspects such as mental models, human information processing, critical thinking, metacognition (understanding one's own cognitive processes), self-regulation, and integration of knowledge with prior learning. Learning should support true understanding and the formation of internal knowledge structures. This, in turn, leads to retention and facilitates transfer to skills in other domains. New knowledge encountered should build on prior learning.

The cognitive approach views the process of learning and the cultivation of cognition as more important than the generation of learning products by learners. Educators who subscribe to cognitivism encourage learners to develop critical thinking skills and to reflect on their own learning. Ways of attaining this are authentic problem solving or explicit teaching of cognitive strategies alongside content knowledge. Some of the researchers who have contributed to the development and growth of the cognitive paradigm, including classic authors, are Anderson (1983), Gagné & Merrill (1990), Inhelder & Piaget (1958), Jonassen, Campbell & Davidson (1994), Minsky (1975), Newell & Simon (1972), Osman & Hannafin (1992), Reigeluth (1999), Reigeluth & Moore (1999), West, Farmer & Wolff (1991), and Winn (1990).

Constructivism

Constructivism relates to personal knowledge construction and interpretation, active learning, anchored instruction, and multiple perspectives on issues. 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 non-prescriptive; it is not direct instruction, but aims to set up learner-centric environments and activities. Instead of using educational technology to teach content and emphasize performance, constructivism uses e-learning to promote participative learning, active involvement and situated learning that can be applied in the real world. Closely associated are collaborative activities and research by learners, using a variety of resources (Bruner, 1967; 1994; Duffy & Jonassen, 1991; Hannafin, Hannafin, Land & Oliver, 1997; Jonassen 1994; 1999; Reeves & Reeves, 1997; Winn, 1992).

Constructivists believe in integrated assessment in rich and complex contexts or the evaluation of learners' problem-solving skills (Jonassen, 1992). Evaluation should be flexible and decontextualized testing should be avoided. Goals of learning can be negotiated with learners and the resulting objectives can be used in guiding learning and assessment. Evaluation can include self-evaluation. Another notable aspect is the constructivist view of errors, proposing that people learn from making mistakes (Squires & Preece, 1999). Constructivists have reservations about approaches that help learners avoid mistakes, believing that mistakes help learners establish tentative beliefs, which are challenged and may change when they encounter new information (Hannafin, 1992). According to Lebow (1993), errors can be viewed as positive stimulants that create disequilibrium, leading to reflection and restructuring. Finally, constructivist approaches can lead to 'cognitive conflict' and 'cognitive complexity' (Perkins, 1991) when educators withhold explicit teaching and direct solutions. Some learners (and some educators) find this disturbing and prefer systematic teaching.

Initially, the constructivist-behaviourist debate, while criticizing the behaviourist approach and promoting constructivist principles, fell short of proposing practical ways of implementing constructivist learning. The very idea of a 'constructivist instructional design model' was a contradiction in terms! By the mid to late 1990s, however, there was an impact on practice with the advent of constructivist design and suggestions for ways of using technology (Cennamo, Abell & Chung, 1996; Hannafin, Land & Oliver, 1999; Jonassen, 1999; Jonassen & Rohrer-Murphy, 1999; Land & Greene, 2000; Lebow, 1993; Willis, 2000; Willis & Wright, 2000).

Customization

The movement towards customizing, or individualizing, learning (Alessi & Trollip, 2001; Bruner, 1967; Norman & Spohrer, 1996; Reigeluth, 1999) aims for learner-centric instruction that is adaptable to individual learners and allows them to take the initiative regarding (some of) the methods, time, place, content, and sequence of learning. It supports learner-control, negotiated goals, and aims to meet learners' needs and interests.

In behaviourist products and in some cognitive educational software, customization refers to branched system control over the material presented and its sequence. In cognitive situations tending towards constructivism, learners can take the initiative by managing their own progress and may select learning activities. In true constructivism, customized learning is even more open – goals are negotiated, with learners possibly even selecting the topic/s they investigate, as well as the approach and resources. An interesting form of customization occurs when learners use an artefact or tool in an original, unintended manner. This is termed 'incorporated subversion' (Squires, 1997).

Collaboration and communication

Collaborative learning involves joint work, social negotiation, a team approach, accountability, and peer evaluation, i.e. sharing responsibility within a group. It optimizes on complementarity and instils collaborative skills in learners (De Villiers & Cronjé, 2005; Nelson, 1999; Panitz, 1996; Singhanayok & Hooper, 1998). Its leading proponents in the 1990s, Johnson & Johnson (1991), describe the key elements of cooperative and collaborative learning as being shared goals, positive interdependence, individual and joint accountability, the ability to communicate, interpersonal skills, empowerment of learners and cooperative assessment. Collaborative learning often occurs within constructivism (Duffy & Jonassen, 1991). Nelson (1999) discusses collaborative problem solving, describing how groups of learners tackle tasks requiring complex knowledge and skills. This expertise can be combined in different ways to complete the tasks successfully.

Before the Internet, collaboration was mainly restricted to class-based teaching and other face-to-face situations. This has been transformed as the Internet and digital technologies change the face of learning and communication, bringing spatial independence and offering a variety of forms of synchronous and asynchronous collaboration. Such communication, whether between educator and learner or learner and fellow-learner, simulates the features of contact learning by providing social interaction.

Components

While it is clear that the HCMm has a cognitive bias, its framework includes components of learning and instruction (Reigeluth, 1999) in the belief that some types of skills and learning are better communicated by an instructivist approach that decontextualizes certain knowledge in order to teach it. Components relate to the basic knowledge, skills and methods of a domain – entailing unitary components and composite components, as well as decontextualized skills.

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 can effectively achieve its instructional goals. Each learning objective or outcome is related to the appropriate content and desired performance, resulting in an instructional component that is positioned on a two-dimensional performance-content grid. Merrill (2001) emphasizes the use of instructional components as theoretical tools in the design of effective, efficient and appealing instructional products, both in directive tutorial material and in environments for experiential learning.

Creativity and motivation

Designers of instruction should aim to support the affective aspects of learning, seeking creative and innovative instructional strategies and aiming for novelty within functionality in ways that motivate learners intrinsically (Dick 1995; Jones, 1998; Malone, 1981). The motivational ARCS Model of Keller & Suzuki (1988) advocates gaining attention, ensuring relevance, instilling confidence, and achieving learner-satisfaction. Research into the cognitive and affective domains shows that the cognitive and emotional subsystems of the brain are highly interrelated (Price, 1998; Wager, 1998), emphasizing the importance of motivating learners. A successful creative method or product should engage learners, inducing *flow* (Csikszentmihalyi, 1990) – an optimal experience in which participants are deeply engrossed and enjoy an activity. HCMm research (De Villiers & Cronjé, 2005) shows that creativity fosters creativity, as novel learning situations stimulate learners to embrace De Bono's (1970) lateral thinking. Caropreso and Couch (1996) stress the value of creativity and innovation in workplace training, and suggest that creative design skills can be learned by educators.

There is convergence between the disciplines of human-computer interaction (HCI) on the one hand, and instructional design and learning theory on the other. Software usability is important for professionals in the workplace, yet how much more important it is to aim for high usability and supportive interaction in e-learning, where learners are first exposed to a web site or courseware before they can even begin to engage with the learning functionality. To support and motivate learners, HCI principles regarding interface design, interaction design and usability (Dix, Finlay, Abowd & Beale, 2004; Preece, Rogers & Sharpe, 2002) should be applied.

General

The design and implementation of e-learning, particularly in the context of OBE, can be enhanced by discerningly considering the six HCMm elements and applying those appropriate to the content and context of each domain. It is not the intention that each application should conform to all six. The HCMm can also serve as an evaluation approach from the perspective of learning theory. It has been applied in South African higher education and training (De Villiers, 2000, De Villiers & Dersley, 2003; De Villiers & Queiros, 2003; De Villiers & Cronjé, 2005).

RELEVANCE OF THE HCMm to OBE

Goodwin-Davey (2000) calls for recognition of the connections between OBE and basic principles of good learning, citing specifically: multiple literacies and multiple intelligences, contextualized learning, acknowledgement of cultural diversity, communication skills in all disciplines, self-empowerment, critical thinking skills, collaborative group work, and learner-centricity. The HCMm can be considered as one response to that call, since Goodwin-Davey's stated principles are explicitly addressed within the HCMm.

Before outlining the relevance of the HCMm for OBE, however, two perspectives on educational technology are mentioned. First, the use of technology varies according to the learner-content relationships defined in Winn's (1992) *full* and *empty* instructional technologies. A full technology contains information to be transferred interactively to students, e.g. tutorials and CAI lessons. An empty technology is a shell that supports exploration, communication and construction, e.g. searches and generation of products using the Internet, constructivist learning environments and use by learners of commercial software as tools for documentation, data manipulation and collaboration.

The second attribute relates to the type of subject matter inherent in the content domain. There is a difference between *well-structured* and *ill-structured* domains (De Villiers, 2005; Hannafin, Land & Oliver, 1999; Jonassen, 1999). Well-structured (or 'closed') domains contain tightly defined concepts, for example, syntactic, scientific and mathematical content, where rules, procedures or algorithms are prescribed. Ill-structured (also called 'open') domains are characterized by problems with multiple solutions and alternate approaches, such as the social sciences, management sciences, environmental disciplines and design disciplines, which require reflective practice (Schön, 1987), expert-type knowledge and heuristic processes.

E-learning can contribute towards the critical outcomes of OBE, and the HCMm in turn can enhance e-learning as already shown in Figure 1. There is compatibility between the HCMm and the OBE outcomes proposed by the National Department of Education (South Africa, 1998; South African Qualifications Authority, 2001). Figure 3 and the ensuing discussion show how the ethos and elements of the Hexa-C Metamodel are related to the seven critical outcomes and can be mapped onto them. Where an element, if appropriately used, contributes directly towards achieving an outcome, the cell in the matrix is marked **D**. Where it can play an indirect role, it is indicated by **I**.

Critical outcome of OBE	**Element of HCMm framework**					
	Cognitive learning	Constructivism	Customization	Collaboration and communication	Components	Creativity and motivation
Problem-solving skills	D_1	D_2	D_3	I	D_4	D_5
Teamwork		D_6		D_7		
Self-responsibility	D_8	D_9	D_{10}	I	D_{11}	D_{12}
Research skills	D_{14a}	D_{13}			D_{14b}	
Communication skills		D_{15}		D_{16}	D_{17}	I
Technological and environmental literacy	I	D_{18}	I	I	D_{19}	
Macrovision		D_{20}			I	

Figure 3. Relationship between HCMm e-learning and OBE critical outcomes

The following subsections suggest ways in which HCMm elements can support the designer of e-learning within OBE, structured according to the seven critical outcomes and referring to the cells of Figure 3. As stated in the introduction, the approaches suggested, some of which are advocated by De Villiers (2003) in a more general context and at a different forum, are not specific to any content domain. They are generic strategies and learning activities to be instantiated by the e-learning educator or multimedia developer, who can contextualize them to particular e-learning situations.

Problem solving

Good problem solving involves making decisions by applying prior knowledge to the problem in hand, as well as by critical and creative thinking (Cell D_5 in Figure 3). Creative strategies (De Bono, 1970) and reflective means (Schön, 1987) must be used to address the situation. In presenting problems to learners, phenomena can be represented by multi-media − video, animations, etc. 'Challenge' activities can require learners to identify the underlying theoretical concepts, which stimulates higher-order thinking skills (HOTS). Cognitivism stresses the integration of new knowledge with prior learning (D_1). The relationship between theory and practice may be addressed deductively – with learners reviewing concepts and rules before applying them, or inductively – moving from examples to underlying theory. Problem solving in closed domains is based more on given information than on sources searched out by learners. Supportive, diagnostic, individualized (D_3) feedback by educators can foster cognition within the problem-solving process.

Constructivist approaches (D_2) can be used for exploration and discovery learning beyond the basics, for example, searches and interactive problem solving, particularly in open domains. Learners' understanding can be anchored prior to problem solving by the provision of non-examples (as well as examples) of concepts and by the requirement that learners themselves synthesize examples of the concepts learned. Moreover, there is a natural relationship between the freedom of the

Internet/WWW environments and constructivist frameworks (Hedberg, Brown & Arrighi, 1997). The Net and Web offer active, learner-centric problem-solving experiences, but must be used with sound pedagogy (Firdyiwek, 1999; Winn, 1999).

Procedural domains usually require explicit teaching of components of knowledge. This may appear at odds with outcomes-based education where personal knowledge construction and interpretation, as described in the previous paragraph, are the antithesis of componential instruction, yet the two are compatible and complementary. Examples and exercises in problem solving can themselves be available as components to be selected by learners (D_4). Interactive practice environments can be designed to offer far more than the conventional computer-based, program-controlled drill. Visual templates outlining generic steps within structured procedures can support learners as they tackle exercises, and scaffolding components can be designed to integrate theory as required. The *principles* and *procedures* of Merrill's (1983) CDT can be considered as composite components for applying theory and moving beyond unitary components such as CDT's *facts* and *concepts*.

Teamwork (closely related to Communication)

For a real-life outcome, OBE requires that learners are able to work effectively in a team/group. Initially, this appears to be a form of learning restricted to particular contexts. For example, collaborative learning (D_7) may not be considered suitable for well-structured algorithmic tasks with tightly defined procedures. However, experience has shown that spontaneous joint use of e-learning tutorials and interactive practice environments intended for individual use can occur (De Villiers, 2000). Co-operative work by small groups at workstations is an effective way of learning and building confidence, whether it relates to absorbing foundational knowledge or to developing solutions to problems (D_6). Peer teaching can help to consolidate concepts. Contact learning in open, ill-structured domains provides an excellent infrastructure for teamwork, joint projects, collaboration and data sharing (D_7). Role allocation should capitalize on skills and strengths and ameliorate weaknesses, providing an efficient approach to heuristic tasks that require complex knowledge and varied expertise. Furthermore, it is preparation for the real world and the workplace. Distance collaboration is more complex, but can be implemented using electronic communication such as e-mail, bulletin boards and discussion forums. Clear definition of roles and rules is required.

Self-responsibility

Of all the critical outcomes, self-responsibility in organizing and managing oneself and one's activities responsibly and effectively, is probably the most critical for the tertiary learner and, as such, is given comprehensive attention in this paper. Educators can facilitate self-responsibility by supportive electronic structures. In well-structured domains, there is a valid role for instructivist forms of e-learning such as cognitively oriented computer-based tutorials (D_8), which present knowledge incrementally – step-wise and chunked, possibly alternating instruction with question segments and learner activities. Self-regulation as required by OBE can be implemented by incorporating strong learnercentricity in the form of learner control (D_{10}) over activities, sequence, time spent and re-views, over and above self-paced work. Such activities can be done in the time and place of the learner's choice. Open-ended work in less structured domains provides auto-customization or customization-by-content. For the former, learners select a personal approach within set content, using tools and techniques of their own choice, and in the latter, they determine their own content within a broad scope. Although componential instruction is not part of open-ended problem solving, basic components should be available even within the less-structured domains (D_{11}). For example, in constructivist learning environments, there can be linked electronic access to knowledge resources, so that learners can contextualize components and integrate them as required.

Educators should capitalize on the cognitive-affective connection (D_{12}). Values and emotions influence the ability to learn and thus impact on self-responsibility and attitude. Intrinsic motivation supports cognition and perseverance. Novel, innovative environments help to engage learners, provided that they are inherently part of the learning experience and not creeping featurism or distracting 'bells-and-whistles'. In well-structured domains, multi-media presentations can serve as multi-gate reinforcement, where appropriate. In less structured domains, open learning systems, particularly web-based 'virtual classrooms', offer scope for informality and humour. The designer of e-learning is rewarded when learners experience 'flow' (Csikszentmihalyi, 1990), forgetting time and tackling more than envisaged! A word of warning, however: the achievement-oriented learner may also require extrinsic motivation and recognition of performance.

Ways of motivating adults are content and values (D_{12}). In applied disciplines and in market-related training, real-world problem solving and authentic tasks (D_9) can lead to *content* being the driver. Capstone projects and integrated assessment can be done in the context of the learners' professions, encouraging them to take the initiative and develop workplace-related artefacts that can lead to career development. In such cases, learners do the computing, using software tools to manipulate and present information. For example, spreadsheets can be used as cognitive tools to display findings and manipulate parameters. Graphics packages and animation can be used to convey information. Learners can develop multi-media products and create websites on which to post the products they generate. Such tasks may well lend themselves to collaborative work, customized for each individual as they take a specialized role (D_{10}).

Particularly in open domains, the hyperlinked environment of the WWW and Internet is ideal for self-regulated constructivist learning with alternative approaches (D_9). In problem-based and project-based learning, a problem (or question) drives the learning as learners explore resources − Internet or databases, generate personal interpretations and propose solutions. Authentic tasks prevent the simplification of complexity and lead to experiential learning as information is accessed on a need-to-know basis. Although this type of learning can lead to cognitive conflict and initial 'constructivist frustration', strategic exploration of erroneous paths leads to reconfiguration, reflection and restructuring. This paragraph and the previous one relate to 'emptier' uses of technology, focusing on exploration, construction, communication and presentation.

Under the most idealistic OBE ethos, evaluation should be aimed at determining learning gain with little 'threatening' grading. Though not feasible in the tertiary context, this is in line with constructivism (D_9) and assessment can incorporate multimodality in the form of online portfolios and journals, as well as self-evaluation and peer-evaluation. In a view that recognizes the worth of individual perceptions (whether correct or not), errors can play a role, leading to restructuring of information.

Research skills

Research requires commitment and focus and a sound background of fundamental prior learning (D_{14a} and D_{14b}) upon which to base, and within which to integrate, new knowledge. Conducting research calls for painstaking self-discipline and rigour, as a candidate collects, analyses, organizes and evaluates information. Independent searches and interpretation of information are more difficult than absorbing and regurgitating knowledge imparted by teachers. Constructivist approaches can support research by presenting the required material in multiple modes (audio, visual, textual, interactive graphics, etc.), and by taking varying perspectives on the subject matter (D_{13}). Going even further, learners should undertake independent electronic searches for information on the Internet and WWW, but should exercise discernment and caution as they scrutinize resources for validity and reliability, assessing them against Smith's (1997) criteria of accuracy, authority, currency, uniqueness, external links, and writing quality. Postgraduate learners should use reviewed sources only.

Communication skills (also related to Teamwork)

In order to demonstrate learning, it is essential that learners can communicate effectively by oral and written means, using domain-appropriate notations. Basic teaching and training in these skills must be provided in the educational system (D_{17}). Literacy requires basic reading and writing, which can be taught in different ways, but must include the fundamental components of spelling, syntax and semantics. Similarly, numeracy requires explicit teaching of notations and operations. At tertiary level, one would assume that these foundations exist, but this is not always the case. Bridging and access courses may be required and in such situations, self-paced computer-based tutorials and drills can play a role. Outcome 2, Teamwork, contributes to advanced language and/or written skills (D_{16}) as learners direct, communicate and negotiate meaning (D_{15}). Teamwork does not always occur face-to-face. Participation in online forums and e-mail can be used as supporting or supplementary means, since they teach users concise yet meaningful communication.

Technological and environmental literacy

This outcome, relating to the effective and responsible use of science and technology, is an intrinsic part of the ethos of this paper. Whether e-learning is a supplement to contact-teaching or whether it is applied in distance-education, technology should be used in a responsible way by the deliverers/facilitators, so that it implicitly and contextually demonstrates sound use. Explicit teaching (D_{19}) on ethical aspects and information security, for example, topics such as plagiarism and netiquette, should be provided in any situation where learners are exposed to e-learning, whether as a means of delivery, exploration, communication or construction of products. In particular, real-world activities (D_{18} and other entries in the Constructivism column) enforce standards beyond the norm for academia, demanding superior efforts that are experiential training for effective and responsible use of technology. Peer teaching of technological skills tends to occur naturally (note the I in Collaboration column).

Macrovision – understanding inter-relationships between systems

Understanding of the world as a set of related systems is a higher-order thinking skill, which can evolve as learners develop insight and integrative skills. Constructivist learning (D_{20}), in particular, seeks to foster this type of interpretation and, although this seventh critical outcome is not explicitly supported by the HCMm, it could well be achieved as a consequence of the experiential and holistic thinking involved in personal knowledge construction.

General

The movement within e-learning towards reuse of so-called 'learning objects' is rapidly gaining momentum. In a similar way to that in which South Africa's national DOE presents general OBE curricula for school learners (Thutong Portal, ongoing), various repositories of tertiary courseware are available in open source sites for general access. Material is available for biology, calculus, chemistry, computer science, economics, and many other courses at sites such as the Open Learning Initiative of the Carnegie Mellon University (Open Learning Initiative, 2003).

CONCLUSION

The design and implementation of e-learning can be enhanced by discerningly considering the six HCMm elements. On a generic level, design guidelines and practical suggestions − such as those in this paper − support e-learning that conforms both to the HCMm and that fosters particular outcomes, over and above knowledge gain. On a specific level, these can be contextualized to generate learning activities and resources that contribute to meeting the critical outcomes for particular learning domains, contexts and content. Some of the most useful e-learning applications and activities that the educator or designer of learning can consider are:

- Interactive learning environments;
- Web-based educational resources / online courseware;
- Open-ended learning environments and constructivist learning environments;
- Direct instruction via hyperlinked textbooks, workbooks, lessons, and CAI tutorials;
- Multi-media productions and videos;
- Internet searches;
- Digital learning communities;
- Online communication; and
- Use by learners of computers as tools.

Principles from the disciplines of learning theory, instructional design, and human-computer interaction — as synthesized in the HCMm — should be applied in the development of learning resources and web-based environments that facilitate effective and affective learning. In particular, it is important that e-learning resources adhere to established principles of learning theory. Resources that implement appropriate elements of the HCMm can satisfy several critical outcomes and can assist educators in meeting some of the challenges of tertiary education in South Africa.

ACKNOWLEDGMENTS

Gratitude is due to Prof Seugnet Blignaut, Professor in Educational Technology, Tshwane University of Technology for valuable referral to sources. Appreciation is also due to Ms Danielle Heyns, CES: Curriculum Innovation and e-Learning, Department of Education, South Africa, for personal communications.

REFERENCES

1. Alessi, S.M. & Trollip, S.R. 2001. *Multimedia for learning: methods and development*. Englewood Cliffs, N.J.: Prentice Hall.
2. Anderson, J.R. 1983. *The architecture of cognition*. Cambridge MA: Harvard University Press.
3. Bruner, J.S. 1967. *Toward a theory of instruction*. Cambridge Mass: Harvard University Press.
4. Bruner, J. 1994. *Constructivist Theory*. Retrieved June 2006, from: http://tip.psychology.org/bruner.html
5. Catherall, P. 2005. *Delivering e-learning for information services in higher education*. Oxford: Chandos Publishing.
6. Caropreso, E.J. & Couch, R.A. 1996. Creativity and innovation in instructional design and development: the individual in the workplace. *Educational Technology*, 36(6): 31-39.
7. CEDEFOP (European Centre for the Development of Vocational Training) 2002. *E-learning and training in Europe*. Luxembourg: Office for Official Publications of the European Communities.
8. Cennamo, K.S., Abell, S.K. & Chung, M. 1996. A "Layers of Negotiation" model for designing constructivist learning laterials. *Educational Technology*, 36(4): 39-48.
9. Clark, R.C. & Mayer, R.E. 2003. *e-Learning and the science of instruction*. San Francisco, CA: Pfeiffer.

10. Csikszentmihalyi, M. 1990. *Flow: the psychology of optimal experience*. New York: Harper and Row.
11. De Bono, E. 1970. *Lateral thinking: a textbook of creativity*. Harmondsworth: Penguin Books.
12. De Villiers, M.R. 2000. Evaluation of an interactive learning environment: theory and practice. *South African Journal of Higher Education*, 14(3): 120-131.
13. De Villiers, 2003. Foundation for structure: a learning theory approach to instructional design for e-learning. *International Journal of learning Vol 10. Proceedings of the Learning Conference 2003*: 595-607. Melbourne: Common Ground Publishing.
14. De Villiers, M.R. 2005. e-Learning artefacts: Are they based on learning theory? *Alternation* 12 (1b): 345-371.
15. De Villiers, M.R. & Cronjé, J.C. 2005. Six learning theory perspectives on a Web-based learning environment. *South African Journal of Higher Education*, 19(3): 444-466.
16. De Villiers, M.R. & Dersley, R. 2003. Emerging technology for emerging peoples: evaluation of an African AIDS-awareness training system. *Proceedings of Ed-Media 2003 World Conference on Educational Hypermedia & Telecommunications*. Honolulu, USA.
17. De Villiers, M.R. & Queiros, D.R. 2003. Real-world problem-based learning: a case study evaluated. *South African Journal of Higher Education*, 17 (1): 112-122.
18. Dick, W. 1995. Instructional design and creativity: a response to the critics. *Educational Technology*, 35(4):5-11.
19. Dix, A., Finlay, J., Abowd, G.D. & Beale, R. 2004. *Human-computer interaction*. (3rd ed.). Harlow: Pearson Education, Ltd.
20. Duffy, T.M. & Jonassen, D.H. 1991. Constructivism: new implications for instructional technology? *Educational Technology*, 31(5): 7-12.
21. Erskine, J. 2003. Learning and teaching support network: Resource guide in virtual learning environments (VLEs). Retrieved July 2004, from: http://www.hlst.ltsn.ac.uk/projects/Specialists/erskine.pdf
22. Firdyiwek, Y. 1999. Web-based courseware tools: where is the pedagogy? *Educational Technology,* 39(1): 29-34.
23. Gagné, R.M. & Merrill, M.D. 1990. Integrative goals for instructional design. *Educational Technology Research & Development*, 38(1): 23-30.
24. Goodwin-Davey, A. 2000. To OBE or not to OBE: This is no longer the question. *Progressio*, 22(1).
25. Hannafin, M.J. 1992. Emerging technologies, ISD, and learning environments: Critical perspectives. *Educational Technology Research & Development*, 40(1): 49-63.
26. Hannafin, M.J., Hannafin, K.M., Land, S.M. & Oliver, K. 1997. Grounded practice and the design of constructivist learning environments. *Educational Technology Research & Development*, 45(3): 101-117.
27. Hannafin, M., Land, S. & Oliver, K. 1999. Open learning environments: foundations, methods, and models. In: C.M. Reigeluth (Ed.) *Instructional-design theories and models Volume II: A new paradigm of instructional theory*. Mahwah, N.J.: Lawrence Erlbaum Associates.
28. Hedberg, J., Brown, C, & Arrighi, M. 1997. Interactive multimedia and web-based learning: Similarities and differences. In Kahn, B.H. (Ed.), *Web-based instruction*. Englewood Cliffs, N.J: Educational Technology Publications.
29. Inhelder, B. & Piaget, J. 1958. *The growth of logical thinking from childhood to adolescence*. New York: Basic Books Inc. Publishers.
30. Johnson, D.W. & Johnson, R.T. 1991. *Learning together and alone*. Englewood Cliffs, N.J.: Prentice Hall.
31. Jonassen, D.H. 1992. Evaluating constructivistic learning. In: T.M. Duffy & D.H. Jonassen (Eds) *Constructivism and the technology of instruction: A conversation*. Hillsdale, N.J: Lawrence Erlbaum Associates.
32. Jonassen, D.H. 1994. Thinking technology: towards a constructivist design model. *Educational Technology*, 34(4): 34-37.
33. Jonassen, D. 1999. Designing constructivist learning environments. In: C.M. Reigeluth (Ed.) *Instructional-design theories and models Volume II: A new paradigm of instructional theory*. Mahwah, N.J.: Lawrence Erlbaum Associates.
34. Jonassen, D.H., Campbell, J.P. & Davidson, M.E. 1994. Learning with media: restructuring the debate. *Educational Technology Research & Development*, 42(2): 31-39.

35. Jonassen, D.H. & Rohrer-Murphy, L. 1999. Activity Theory as a Framework for Designing Constructivist Learning Environments. *Educational Technology Research & Development*, 47(1):61-79.
36. Jones, M.G. 1998. Creating engagement in computer-based learning environments. *ITForum Paper #30*. Retrieved June 2006, from: http://it.coe.uga.edu/itforum/paper30/paper30.html
37. Keller, J.M. & Suzuki, K. 1988. Use of the ARCS motivational model in courseware design. In: D.H. Jonassen (Ed.) *Instructional designs for microcomputer courseware*. New Jersey: Lawrence Erlbaum Associates.
38. Kilfoil, W.R. 1999. The comfort zone stops here: OBE, the NQF and higher education. *Scrutiny2,* 4(1): 3-15.
39. Killen, R. 2000. Outcomes-based education: principles and possibilities. Retrieved June 2005, via: http://scholar.google.com/
40. Land, S.M. & Greene, B.A. 2000. Project-based learning with the World Wide Web: a qualitative study of resource integration. *Educational Technology Research & Development*, 48(1): 45-68.
41. Lebow, D. 1993. Constructivist values for instructional systems design: five principles toward a new mindset. *Educational Technology Research & Development*, 41(3): 4-16.
42. Malone, T.W. 1981. Toward a theory of intrinsically motivating instruction. *Cognitive Science*, 4: 333-369.
43. Merrill, M.D. 1983. Component display theory. In: C.M. Reigeluth (Ed.) *Instructional design theories and models: an overview of their current status*. Hillsdale, N.J: Lawrence Erlbaum Associates.
44. Merrill, M.D. 2001. Components of instruction toward a theoretical tool for instructional design. *Instructional Science*, 29: 291-310.
45. Minsky, M.L. 1975. A framework for representing knowledge. In: P.H. Winston (Ed.) *The psychology of computer vision*. New York: McGraw-Hill.
46. Nelson, L.M. 1999. Collaborative problem solving. In: C.M. Reigeluth (Ed.) *Instructional-design theories and models Volume II: A new paradigm of instructional theory*. Mahwah, N.J: Lawrence Erlbaum Associates.
47. Newell, A. & Simon, H.A. 1972. *Human problem solving*. Englewood Cliffs, N.J: Prentice-Hall Inc.\
48. Norman, D.A. & Spohrer, J.C. 1996. Learner-centered education. *ITForum Paper #12*. Retrieved June 2006, from: http://it.coe.uga.edu/itforum/paper12/paper12.html
49. Open Learning Initiative (OLI) 2003. Carnegie Mellon University. Retrieved June 2006, from: http://www.cmu.edu/oli/index.html
50. Osman, M.E. & Hannafin, M.J. 1992. Metacognition research and theory: analysis and implications for instructional design. *Educational Technology Research & Development*, 40(2): 83-99.
51. Panitz, T. 1996. A definition of collaborative versus cooperative learning. Retrieved June 2006, from: http://www.lgu.ac.uk/deliberations/collab.learning/panitz2.html
52. Price, E.A. 1998. Instructional systems design and the affective domain. *Educational Technology*, 38(6): 17-28.
53. Perkins, D.N. 1991. Technology Meets Constructivism: Do They Make a Marriage? *Educational Technology*, 31(5): 18-22.
54. Preece, J., Rogers, Y., & Sharp, H. 2002. *Interaction design*. New York: John Wiley & Sons.
55. Reeves, T.C. & Reeves, P.M. 1997. Effective dimensions of interactive learning on the World Wide Web. In: Khan. B.H. (Ed.). *Web-Based Instruction.* Englewood Cliffs, N.J: Educational Technology Publications.
56. Reigeluth, C.M. 1999. What is instructional-design theory and how is it changing? In: C.M. Reigeluth (Ed.) *Instructional-design theories and models Volume II: A new paradigm of instructional theory*. Mahwah, N.J: Lawrence Erlbaum Associates.
57. Reigeluth, C.M. & Moore, J. 1999. Cognitive education and the cognitive domain. In: C.M. Reigeluth (Ed.) *Instructional-design theories and models Volume II: A new paradigm of instructional theory*. Mahwah, N.J: Lawrence Erlbaum Associates.
58. Schön, D.A. 1987. *Educating the reflective practitioner*. San Francisco: Jossey-Bass Publishers.
59. Singhanayok, C. & Hooper, S. 1998. The effects of cooperative learning and learner control on students' achievement, option selections, and attitudes. *Educational Technology Research & Development*, 46(2): 17-33.

60. Smith, A.G. 1997. Testing the Surf: Criteria for Evaluating Internet Information Resources. *The Public-Access Computer Systems Review,* 8(3). Retrieved June 2006, from: http://info.lib.uh.edu/pr/v8/n3/smit8n3.html
61. Spady, W.G. 1994. *Outcomes-based education: critical issues and answers*. Arlington, VA: American Association of School Administrators.
62. Squires, D. 1997. An heuristic approach to the evaluation of multimedia software. Retrieved December 2005, from http://www.media.uwe.ac.uk/masoud/cal-97/papers/squires.htm
63. Squires, D. & Preece, J. 1999. Predicting quality in educational software: Evaluating for learning, usability and the synergy between them. *Interacting with Computers*, 11(5): 467–483.
64. South Africa 1998. Green Paper on Further Education and Training. Retrieved June 2006, from: http://www.polity.org.za/govdocs/green_papers/furtheredgp4.html
65. South African Qualifications Authority 2001. The National Qualifications Framework: An overview. Retrieved June 2006, from: http://www.saqa.org.za/show.asp?main=structure/nqf/overview01.html
66. Thutong South African Educational Portal. Date: ongoing. Department of Education, South Africa. Retrieved June 2006, from http://www.thutong.org.za/
67. Venter, M. 2000. Assessing the assessment of outcomes-based education. Retrieved June 2006, from: http://www.apapdc.edu.au/archive/ASPA/conference2000/papers/art_3_9.htm
68. Wager, W. 1998. Social determinants of affective behavior and learning. *Educational Technology*, 38(6): 15-16.
69. West, C.K., Farmer, J.A. & Wolff, P.M. 1991. *Instructional design: implications from cognitive science.* Englewood Cliffs, N.J.: Prentice Hall.
70. Wesson, J.L. & Cowley, N.L. 2003. The challenge of measuring e-learning quality: Some ideas from HCI. *IFIP TC3/WG3.6 Working Conference on Quality Education @ a Distance*: 231-238. Geelong: Australia.
71. Willis, J. 2000. The maturing of constructivist instructional design: some basic principles that can guide practice. *Educational Technology*, 40(1): 5-16.
72. Willis, J. & Wright, K.E. 2000. A General Set of Procedures for Constructivist Instructional Design: The New R2D2 Model. *Educational Technology*, 40(2): 5-20.
73. Winn, W. 1990. Some implications of cognitive theory for instructional design. *Instructional Science*, 19(1): 53-69.
74. Winn, W. 1992. The assumptions of constructivism and instructional design. In: Duffy, T.M. & Jonassen, D.H. (Eds.), *Constructivism and the technology of instruction: a conversation*. New Jersey: Lawrence Erlbaum Associates.
75. Winn, W. 1999. Learning in virtual environments: a theoretical framework and considerations for design. *Educational Media International*, 36(4): 271-279.