THE DYNAMICS OF THEORY AND PRACTICE IN INSTRUCTIONAL SYSTEMS DESIGN

A thesis by

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ABSTRACT

This study investigates the dynamics of theory and practice in the design of instructional systems, learning events and learning environments, with a view to synthesizing an integrated metamodel as a framework to facilitate effective learning in systems which use computer technology as a tutor, tool, or environment. This framework can be used as a design aid by instructional designers and instructor-designers, or as a tool to examine existing learning events from the viewpoint of learning and instructional-design theory. The research contributes to inquiry into learning theory by an in-depth study of the elements of the framework itself, investigating how they function in different contexts and contents.

Following an extensive literature survey, the researcher synthesizes a concise integrated framework of learning theories and instructional design practice from the cognitive family. This framework, the Hexa-C Metamodel (HCMm), is generated by a process of criterion-based textual filtration through effectiveness criteria, and encompasses the theoretical concepts of *constructivism*, *cognitive learning* and *knowledge/skills components*, as well as the practical characteristics of *creativity*, *customization* and *collaborative learning.* Using mainly qualitative ethnographic methods within the contexts of action research and development research, case studies are undertaken, applying the elements of the HCMm as an inquiry toolset to investigate three diverse learning events to determine what they reveal about the practice of effective and motivational learning. The learning events - a computer-based practice environment, an Internet-based course, and a fieldwork project – were selected due to the researcher's close involvement with each intervention. Information from the evaluations of the learning events is then used to further examine in-depth the theories and characteristics which comprise the tool, as well as their interrelationships and ways of implementing them in domains that differ in context and content - distinguishing particularly between well-structured and ill-structured domains.

Key words:

Instructional systems design and development; Learning and instructional theory; Evaluation; Inquiry tool; Computer-integrated learning; Cognitive learning; Collaborative learning; Components of knowledge; Constructivism; Creativity; Customization; Domains of learning.

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2. Department of Teaching and Training Studies, University of Pretoria – for permission to evaluate *RBO880*, the Internet-based course on Computer-Assisted Communication and Management.
3. School of Tourism Management, University of Pretoria – for permission to evaluate the *Mkambati Project* of the Ecotourism course.

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Terminology

This is not a comprehensive glossary of terms. Rather, it is an overview of some generally-accepted, traditional meanings of certain terms in the domain of instruction and instructional design. These terms set the background for this study and form the context out of which the newer approaches such as constructivist learning environments, problem-based learning, etc. evolved.

- ***What is an instructional theory?*** (Reigeluth, 1996c, 1999)

Instructional-design theory:

- is design-oriented - focusing on how to attain goals for learning or development, rather than description-oriented - focusing on the effects of given events.

Instructional-design theory identifies:

- Methods of instruction (ways to support and facilitate human learning and development);
- Situations in which those methods should and should not be used. A major aspect of any situation is the desired instructional outcome (not the same as a learning goal) which sets out the levels of effectiveness, efficiency, and appeal required from the instruction.

The methods of instruction are:

- Componential, in that they comprise different components or features;
- Probabilistic, not deterministic, meaning that they increase the chances, but do not ensure, attainment of the goals.

- ***How does instructional-design theory differ from learning theory?*** (Reigeluth, 1996c, 1999)

Learning theories are descriptive, in that they describe how learning occurs but do not identify or prescibe methods for promoting learning. By contrast, instructional-design theories are applied in practice; they are theories that identify methods for use in particular situations. In short, an instructional-design theory comprises *methods* and *situations*, and relates to events external to learners rather than describing what takes place within learners when learning occurs.

- ***How does instructional-design theory differ from instructional systems development (ISD) processes?***

Instructional-design theory is concerned with the characteristics of the instruction and its methods, not with the processes an instructional designer or teacher would use to plan the instruction. According to Reigeluth (1999), terms which characterize this distinction are:

- Instructional theory, instructional model, instructional strategies - to represent instructional-design theory;
- Instructional development model, instructional systems development (ISD) process -to represent the actual process and procedures of designing instruction. These processes are, however, closely related to underlying theories.

- ***What is instructional design? What are instructional design theory/models, and what does the instructional design process comprise?***

Instructional design (ID) is the link between descriptive learning theory and prescriptive educational practice (Reigeluth, 1997). ID thus comprises prescriptive instructional-design theories and models which set out methods for developing instruction, along with the conditions under which each should be used to produce a desired learning outcome. Instructional designers should be versed both in descriptive learning theories and prescriptive design theories, so that theory and practice can be integrated.

Reigeluth (1983) in his classic, *Instructional-design theories and models, Volume I* describes *instructional design:*

- As a professional activity, whereby decisions are taken as to what methods of instruction are best for bringing about desired changes in student knowledge and skills in a specific content area, and
- As a discipline concerned with producing knowledge about optimal instructional methods, strategies, and combinations of methods (i.e. whole models).

Reigeluth (1999) proposes that *instructional design theory* describes the characteristics of the instruction, i.e. what methods should be used. Analogous concepts are instructional theory, instructional model, and instructional strategies. *The instructional design process* is what a teacher or designer does to plan and prepare for the instruction, also called an instructional development model or instructional systems development (ISD). However, ID theories and ID processes are closely related.

According to Merrill *et al* (1996c), *instruction is a science* and *instructional design is a technology* founded on this science.

- Instructional science is concerned with discovering the natural principles involved in instructional strategies. Sciences are verified by discovery, so instruction, like other sciences, is verified by discovery.
- Instructional design is a man-made technology using those principles to invent procedures and tools that will promote learning. Like other technologies, ID is extended by invention. Design research involves deriving procedures and processes that incorporate the theory learned from instructional science. So *instructional design* is a technology for the development of learning experiences and environments which promote the acquisition of specific knowledge and skill by students. It incorporates known and verified learning strategies into these instructional experiences and environments, so as to make the acquisition of knowledge and skill more efficient, effective, and appealing.
- *Instructional systems development* (ISD) is a set of procedures for systematically designing and developing instructional materials.

Winn (1990) defines *instructional design* as a set of decision-making procedures by means of which the most effective instructional strategies are developed or chosen.

Willis (1995) uses the following simple and paradigm-independent definitions:
Instructional design refers to the process of designing instructional materials; and
An instructional design model refers to a theory or model that can guide the process of instructional design.

- ***What is entailed by instruction?***

Instruction involves directing students to appropriate learning activities, guiding them to appropriate knowledge, helping them rehearse, encode, and process information; monitoring student performance; providing feedback to their learning activities and practice (Merrill *et al,* 1996c).

Dick (1991) defines *instruction* as an organized set of methods, materials, and assessments designed to promote competence in defined outcomes.

Both of the above are definitions of what is known as 'direct instruction'.

Models of instruction

Reigeluth (1989) identifies three basic forms for instructional theories and associated models of instruction:

1. *Intact models,* where a different kind of instruction is prescribed for each of a variety of conditions, for example, Merrill's CDT - section 3.3.3.1;
2. *Variations on a model* where there is one general model and variations of it are prescribed for different conditions; and
3. The 'smorgasbord' paradigm, which has *no formal model* of instruction, but prescribes various methods on a mix-and-match basis according to the conditions.

Chapter One

Introduction

This thesis investigates the dynamics of theory and practice in instructional systems design. The study entails investigation of current learning theories, approaches to the design of instruction, and contemporary instructional philosophies and practices - with a view to synthesizing an integrated metamodel as a framework to facilitate effective learning. The framework is intended to be relevant and applicable to a variety of instructional systems - such as instructional resources and products, interactive learning environments, and open-ended learning experiences - generally termed 'learning events' in this study. The metamodel - a model of models - can be used to examine existing learning events from the viewpoint of instructional and learning theory, and is applied to three case studies. Furthermore, the study makes its own contribution to the inquiry into learning and instructional theories, by undertaking an in-depth study of the elements of the integrated framework itself, investigating the ways in which they function in different contexts and contents. In short, this thesis describes the generation of a synthesis of theory and effective practice - the metamodel - and investigates the dynamics of theory and practice in instructional systems design, by using it as a tool to apply theory to practice and determining, conversely, how practice informs theory.

This study takes cognisance of the use of technology and multimedia in instructional and learning practices. The context envisaged for learning events in this study incorporates computer technology, whether used as tutor, tool, or environment. In the case studies the metamodel's framework is applied to varied learning events: a computer-based practice environment, an Internet course, and a field project using computers as tools.

This chapter sets out the real-world problem in Section 1.1 and lists the research questions in Section 1.2. It briefly addresses the value of the research (Section 1.3), before describing in detail the research goals of the study (Section 1.4) and the research methods used (Section 1.5). In Section 1.6 the limitations and delimitations of the study are given, following which Section 1.7 sets out the overall research design.

Finally, in Section 1.8 the structure of the thesis is illustrated by a diagram, and the content of each chapter is sketched as well as the interrelationships between them.

1.1 Real-world problem statement

Academics and practitioners are addressing the theories of learning and instruction with the aim of understanding learning. Increased understanding of learning should, in turn, enhance the design of instruction and lead to more effective instructional practice. An extensive body of literature exists on theories of learning and the design of instructional resources and learning environments. There is, therefore, a need for a compact and concise, yet not simplistic, synthesis of the current thinking in cognitive learning theory, instructional design theory, and effective practice, to facilitate the tasks of:

- Designing instructional systems and learning events/environments,
- investigating existing systems/events/environments from the viewpoint of learning theory, and
- learning more about the dynamics of theory and practice.

1.2 Research questions and associated subquestions

The following research questions guided the inquiry:

1. What theories and characteristics arise when current learning theory and practice are filtered through effectiveness criteria?
(Addressed in Chapter Four)
2. What do these theories and characteristics reveal about the design and practice of effective learning?
(Addressed in Chapter Five)
3. What, conversely, does the practice of learning and instruction reveal about these theories and characteristics?
(Addressed in Chapter Six)

The purpose of these questions is to elicit information regarding the dynamics between various contemporary learning theories and instructional design/practice. Each of the three questions can be expanded or divided into subquestions:

Research Question 1

What theories and characteristics arise when current learning theory and practice are filtered through effectiveness criteria?

In the context of an extensive literature survey of learning theories from the cognitive family, as well as current theories, approaches, and models for the design and practice of instruction, the following are investigated:

- What are suitable means of 'filtration' to operationalize effectiveness, so as to select the most appropriate theories and practices?
  i.e. *How can elements of a metamodel be determined?*
- Using the stated means of selection as a filter, what theoretical elements should be incorporated in a conceptual framework of learning and instructional design?
  i.e. *What are the theoretical elements of the metamodel?*
- Using the stated means of selection as a filter, what practical factors, such as characteristics and features, influence effective and affective learning within learning events - applications such as interactive learning environments, open-ended learning experiences, and instructional resources and products?
  i.e. *What are the practical elements/characteristics of the metamodel?*

Research Question 2

What do these theories and characteristics reveal about the design and practice of effective learning?

Having selected theoretical and practical elements to comprise the framework of the metamodel, in what ways, and to what extent, are they found to be implemented and manifested, as diverse learning events are evaluated?

i.e. *Using the framework as a tool, what is revealed about the practice of effective learning*?

Three very different case studies were conducted:

- **FRAMES**, an interactive practice environment in Discrete Mathematics.
- **RBO880**, a masters degree course in Internet-based Learning, presented via a web-based classroom.
- **Mkambati 2000**, a collaborative fieldwork project of a postgraduate Ecotourism course.

Research Question 3

What, conversely, does the practice of learning and instruction reveal about these theories and characteristics?

Having used the framework as a tool to evaluate and examine three learning events for implementations of the theoretical elements and manifestations of the practical characteristics and features, what did the practice of learning and instruction reveal about the elements of the framework? i.e. *How did the elements of the metamodel influence learning, and in what way should they impact upon the dynamics of instructional systems design and practice?*

1.3 Value of the research

The large body of literature on current learning and instructional design theories from the cognitive family can be overwhelming to designers and practitioners of instruction. The **compacted and integrated framework of instructional design and learning theory generated in this study**, and named the *Hexa-C Metamodel* (HCMm) offers utility to instructional designers and instructor-designers. As a 'metamodel', it does not propose a specific development model or design process. It is not a 'recipe' nor a 'prescription' - rather, it is a framework, suggesting an interrelated set of cognitive learning theories and instructional design approaches, **to serve as an aid** in the design, development and investigation of learning events and environments.

The integrated framework comprises six Cs - namely: cognitive learning, collaborative learning, components, constructivism, customization, and creativity - to be applied in a contextualized manner within learning events. The inherent value of the study extends beyond assessing the instructional and learning efficacy of the three case studies; it is also the intention of this research to discover amplified aspects of the six C-elements when they are applied in practice as a composite tool.

This study should support designers and practitioners in the pursuit of facilitating effective learning. It should contribute to an understanding of the dynamics of learning and instructional theories; and should inform practice on their relationship to the design, development and delivery of instructional systems and learning environments. The former - the dynamics of learning/instructional theories, can be termed *internal dynamics,* i.e. interrelationships and interaction between the metamodel's elements, and the second form – the dynamic relationships between the framework and instructional design/practice, as explored in the case studies - can be viewed as *external dynamics.* ('*Dynamics*', in this study, should be interpreted as set out above, focusing on interaction between aspects of learning theory, and not on systems theory *per se*, which addresses dynamics within specific systems.)

1.4 Research goal and criteria

In this section, some of the common research goals of educational technology studies are outlined, followed by an explication of the research goal of this particular thesis. The field of the investigation is described - setting the scene for presenting the selection criteria to be used in the synthesis of an integrated framework.

1.4.1 Research goals within educational technology

Reeves (1995; 2000) distinguishes between research goals and research methods (Section 1.5), where research goals are described as being influenced by the researcher's training and epistemological views, as well as by dominant research paradigms. The six major types of research goals commonly pursued by educational technology researchers are (Reeves 2000):

- *Theoretical goals* - explaining phenomena through logical analysis and synthesis of theories and principles and the results of other research (e.g. empirical studies);
- *Action goals* - focused on a particular program, product or method in an applied setting, for the purpose of estimating its effectiveness and worth or improving it.
- *Empirical goals* - the dominant form of educational research - testing conclusions related to theories of teaching, learning, performance, assessment, instructional design, etc. It is usually conducted by experimental or quasi-experimental methods.
- *Interpretivist goals* - drawing on research traditions from sciences such as sociology and anthropology, the interpretivist sets out to show how education works by interpreting phenomena related to experiences of teaching, performance, etc. within certain groups of learners.
- *Postmodern goals* - focused on examining the assumptions of contemporary education to determine whether there are underlying agendas, relating, for example, to aspects of gender or culture.
- *Development goals* - aiming for the dual objectives of developing creative approaches to solving problems in the fields of human teaching, learning, and performance; while simultaneously constructing design principles to guide future development efforts.

1.4.2 Research goals of this thesis

The **primary** research goal of this study, namely, exploration of the field in a quest to select, integrate, and extend knowledge on learning theories and the design/development of instruction - combines the *theoretical* and *development* perspectives described above. Its **secondary** intention - evaluation of case studies - pursues an *action* goal. There is also a **tertiary** goal to obtain further knowledge about learning theories and characteristics in practice, which is a *development* goal with an *interpretivist* approach, since it examines how phenomena differ between, and interrelate within, different kinds of learning. The composite goal, closely related to the three research questions in Section 1.2, therefore is:

To explore the current thinking in cognitively-based learning theory, instructional design theory, and effective practice, so as to develop a compact synthesis that can be used:

1. As a framework or tool to assist in the development of instructional systems, learning products, environments, and events;
2. For evaluating existing products, environments, and events from the viewpoint of learning theory; and
3. For determining further information about the dynamics of theories and characteristics embodied in the framework.

A concise set of positions and stances are sought for the metamodel, which as a whole will comprise a framework of theories and characteristics that capture the essence, strengths, and complexities of learning theories and instructional practice within the cognitive family. The theories and characteristics should conform to the effectiveness criteria listed in Section 1.4.4.

1.4.3 Field of investigation

This literature investigated in this study primarily represents the thinking of the past 10 - 15 years, in particular, resources that have been published since the major debate on constructivism commenced in 1991. Behaviourist tendencies dominated instruction up till the influence of cognitive psychology in the 1980s, and this in turn was followed by the advent of constructivism. The realm of current thinking in cognitive-based learning theory, instructional design theory, and effective practice is a broad and inter-related field, which the researcher had to delimit, since it is impossible to cover all relevant sources. Although the explicit intention in this study is to synthesise the current thinking in learning and instructional design theories from the cognitive family, it was expedient also to overview behaviourist positions, due to their role as the platform from which cognitivism developed. Within the 'cognitive family' the researcher positions constructivism at one extreme as an experiential form of the cognitive sciences (2.4.6), and pragmatic instructionism at the other. The literature surveyed was delimited as follows - sources were studied that incorporate a selection of classic works on the various instructional paradigms and philosophies of learning overviewed, as well as publications by recognised experts in the field. The literature consulted is in the English medium and the main context is instruction and learning that uses technology. Among others, articles are drawn from the journals *Educational Technology*, *Educational Technology: Research and Development*, *Instructional Science*, and the *South African Journal of Higher Education*. The parameters of thinking in this study are also influenced by the realm of *IT Forum* (the online Instructional

Technology Forum), and reference is made to papers from its web site. Various textbooks were consulted, also edited collections of articles and refereed conference papers.

Seminal contributions that served as catalysts for this study, urging the need for a move towards consensus and more compact theory are Reigeluth's (1996a; 1996c) proposals for *new paradigms* of instructional theory and instructional systems development (ISD), i.e. changes in theory and practice. Reigeluth's proposals culminate in *Instructional-Design Theories and Models: Volume II* (Reigeluth, 1999), which contains a diverse array of theories with regard to their situations and underlying values. Duchastel's (1998) *Prolegomena to a theory of instructional design*, poses a further challenge, suggesting the need for a single, full, all-encompassing theory of instructional design. Although this dissertation does not attempt to present a theory or model of instructional design, the metamodel it proposes can be viewed as a move toward integration and a concise, though not simplistic, identification of issues to be borne in mind by instructional designers and instructor-designers.

1.4.4 Selection criteria

This study undertakes an extensive literature review and discussion, following which an analysis, filtration, and synthesis process is conducted to determine appropriate theories and characteristics for the integrated framework. The stances to be selected should conform to the following **effectiveness criteria**, which are substantiated in Table 1.1 in Section 1.4.5. Specifically, stances are required which:

1. *Are **consensus-builders** - methods applicable to situations that **transcend paradigms**;*
2. *Demonstrate **functionality and utility in authentic situations** of learning/training/instruction;*
3. *Are **learning-focused** for situations where the learner's role is predominant;*
4. *Comply with **pragmatic, rather than idealistic** purist, considerations;*
5. *Conform to the requirement that formal instruction incorporates some form of **external assessment/grading** of learners;*
6. *Integrate **affective and cognitive** aspects;*
7. *Incorporate means of **communicating complexity** within the learning domain;*
8. *Are **platform-independent**, in that they are not coupled to a specific, single technology for means of presenting instruction;* and
9. *Prepare learners to **apply skills in practice** and **use knowledge in real life**.*

1.4.5 Motivation for the selection criteria

Table 1.1 establishes the relevance of the selected effectiveness criteria, and explains` why they are used as filtering agents in the process of selecting appropriate instructional and learning theories.

Table 1.1 Motivation for the selection criteria

Number	Selection criterion	Reason for criterion
1	Consensus-builder - methods and stances that can be used in situations which transcend paradigms.	Stress should be laid on the intrinsic value of a stance and its applicability in contexts independent of paradigms, rather than perpetuating the paradigm war of the early 1990s.
2	Demonstrate functionality and utility in authentic situations of training or instruction.	Behaviouristic instruction was systematic and research-validated; constructivism was initially idealistic and theoretical. Disregarding origins, theories and characteristics should be selected that result in effective learning.
3	Learning-focused for situations where the learner's role and interests are predominant.	The discipline of instructional design originated in the USA military, which was instructor-centric. Current thinking tends to the learner-centric - also more appropriate for the life-long learning undertaken by many adults.
4	Pragmatic, rather than idealistic purist, considerations.	The prime aim of a workable, usable theoretical model is a balanced approach.
5	Incorporate some form of external assessment/grading of learners.	This is a requirement of formal educational institutions, and also common in market-oriented training.
6	Integrate affective and cognitive aspects.	Emotions and attitudes should be considered, as well as physical and mental aspects.
7	Incorporate means of communicating complexity within the learning domain.	Learning processes must address the difficult parts of subject matter in order to be effective.
8	Platform-independent for means of presenting instruction	Stances that are inextricably bound to a single specific technology as means of delivery should be avoided.
9	Help learners apply skills in practice and use knowledge in the real world	Learning should be preparation for real life.

These criteria are discussed further in Chapter Four, Section 4.3, where they are used as a filter to extract theoretical stances and practical characteristics to be considered for incorporation in the proposed metamodel. The metamodel is presented as an integrated framework to facilitate effective learning in response to the first research question of Section 1.2.

1.5 Research methods

In the previous section (Section 1.4), it was stated that Reeves (1995; 2000) distinguishes between research goals and research methods - the latter serving as tools in the process of achieving the former. Once the research goals and research questions of a particular study are in place, appropriate research methods can be selected to address the nature and requirements of the problem/s. There is frequently a natural relationship between a goal portrayed in Section 1.4.1 and an associated method from Section 1.5.1.

1.5.1 Research methods for educational technology

Research methods are tools selected once goals and tasks are clear (Reeves 2000). Reeves presents six major types of research methods used by educational technologists:

- *Quantitative* - experimental, quasi-experimental, correlational and other methods primarily involving collection and statistical analysis of quantitative data.
- *Qualitative* - observation, case studies, interviews, etc. involving the collection of qualitative data and its ethnographical analysis.
- *Critical theory* - deconstruction of texts, technologies, or systems, to reveal hidden agendas, disenfranchisement, etc.
- *Historical* - objective and accurate reconstructions of the past, frequently with the aim of substantiating a hypothesis.
- *Literature review* - various forms of research synthesis, primarily involving analysis and integration of other forms of research, for example, meta-analyses.
- *Mixed-methods* - approaches that combine a mixture of research methods - usually quantitative and qualitative - in order to triangulate findings.

1.5.2 Research methods used in this thesis

The research methods used in this study involve several of the above. There is a *literature review* with the goal of exploration, analysis, integration, and synthesis within the broad field of learning theories and instructional design. Then there are the case study evaluations, which combine *qualitative* and *quantitative* research, i.e. a *mixed-method* approach within an action goal. The third facet of the goal, namely, to obtain further knowledge about instruction and learning in practice, is achieved using *qualitative* and *inductive methods* (not mentioned in the list above). The comprehension design of the research is elaborated in Section 1.7.

1.6 Limitations and delimitations of the study

Before the development of this study, it is necessary to set out the researcher's assumptions and various limitations on the field. Four concepts are addressed, namely,

- The view in this study of *instructional systems design* and *instructional systems*,
- the domain of the study and its literature resources,
- a brief comment on research and development perspectives, and
- the view of technology.

1.6.1 View of instructional systems design and instructional systems

The title of the thesis is: *The dynamics of theory and practice in instructional systems design*. In the terminology descriptions at the commencement of the study, various views of instructional design theory and instructional design are set out. Of particular note, in this researcher's view, are the following stances (Reigeluth, 1983; 1997; 1999; the *Terminology* Section; and Section 3.2.3.2):

> Instructional-design theory is concerned with the characteristics of the instruction and its methods.
>
> Instructional designers should be versed both in descriptive learning theories and prescriptive design theories, so that theory and practice can be integrated.
>
> Instructional design is both:
> - A professional activity, whereby decisions are taken as to what methods of instruction are best for bringing about desired changes in student knowledge and skills in a specific content area,
> - A discipline concerned with producing knowledge about optimal instructional methods, strategies, and combinations of methods (i.e. whole models).
>
> According to the classic Dick and Carey systematic model for the design of instruction (1978; 1985; 1990; 1996), the design and development of instruction incorporates evaluation - both formative evaluation within the workplace and summative evaluation on the final product.

The view in this study of the design of instructional systems and learning events goes beyond defining ISD as a process-model or a set of decision-making procedures by means of which the most effective instructional strategies are developed or chosen. Using aspects of the definitions above: **instructional systems design is defined as a broad discipline, encompassing expertise in:**

- **Learning theories;**
- **Instructional design theories and methods/strategies;**
- **The development and delivery of instructional resources / learning environments, and**
- **Evaluation of products/events in use - both formative and summative.**

With regard to **instructional systems**, any system *per se* is considered to comprise input, process, and output subsystems, linked by flow. The study, however, does not focus on the dynamics between those three subsystems and their linkages, but rather on the dynamics between theory and practice.

1.6.2 Domain of the study and its literature

As set out in Section 1.4.3, the study has an **international flavour.** It is not written specifically for the researcher's local territory of South Africa, although it holds relevance here.

In line with the intentions described in the introductory comments to this chapter, the literature resources consulted relate particularly to current learning theories and approaches to the design of instruction, as well as contemporary instructional practices. Consequently, particular stress is laid on sources that describe philosophies, theories, and practices **from the wider cognitive family** with a view to incorporating them in the compact metamodel. A broad and extensive body of literature was consulted in this study, as described in Section 1.4.3. Nevertheless, no literature survey can be absolutely complete, and the possibility exists that a work which some may regard as crucial, may have been missed. For example, the general field of systems theory is not addressed, because the 'dynamics' emphasis in this study is on internal and external dynamics of learning theory, and on the dynamics of theory and practice in design, development and delivery of instructional systems and learning events.

1.6.3 Research and development perspectives of the study

Any study has a particular perspective as a point of departure. By definition this entails that other theoretical or philosophical perspectives are excluded. As is clear from Sections 1.4.2 and 1.5.2, this study is founded on clearly-defined research goals and methods, and does not address the others mentioned in Sections 1.4.1 and 1.5.1.

The research does not culminate in a document of explicit design guidelines nor in an evaluation instrument. Moreover, the researcher recognises the unique content, context, conditions, and circumstances of differing learning events. To propose design 'recipes' would, therefore, be at odds with the open constructivist ethos of this study, which posits that constructivist theory is focused more on principles than on strategies (section 2.8). Rather, the HCMm is a multi-faceted aid to the design, development, delivery, and evaluation of instructional systems and learning events in a range of contexts/situations, based on a view of learning as an active, participative process, whereby learners construct concepts, based on using and transforming their former knowledge and expertise.

1.6.4 Technology in this study

Technology in this study is limited to computer technology, viewing computers in their roles as **presentation and practice tools, communication tools,** and **productivity tools**. Other technologies such as television, video, radio, satellite, and cellular/digital telephones, have been excluded.

1.7 Research design

1.7.1 Research design in this thesis

As stated in Sections 1.4.2 and 1.5.2, this study addresses its different facets in different ways, combining *theoretical* and *development* perspectives as well as pursuing an *action* goal, and using a variety of research methods. This section integrates the research goals of Section 1.4.2 and the methods of Section 1.5.2 by briefly overviewing the three aspects of the research in Table 1.2. The rest of the section elaborates on development research and action research, which play major roles in this thesis, showing how each is used in this study, and the research methods applied within them.

<table>
<tr><th colspan="3">Table 1.2 Research goals and methods of this thesis</th></tr>
<tr><td colspan="3">Goal 1 - Exploration of learning and instructional theories, so as to generate a framework to support development of learning events</td></tr>
<tr><td rowspan="3">Goals</td><td rowspan="3">Theoretical goal
Development goal
(Development of the metamodel, not development of an instructional system)</td><td>Methods</td></tr>
<tr><td>Literature review:
Meta-analysis of learning theories, characteristics of instruction, and the design of instruction.</td></tr>
<tr><td>Analysis and integration of literature and results of other research:
Textual filtration and synthesis of a metamodel as a concise and creative framework to aid development of learning/teaching events and products.
Motivation / elaboration: First, the selection criteria for the filtration process are defined. These are compiled by the researcher, based on requirements which, according to certain experts, support effective learning. In this study they are termed effectiveness criteria (1.4.4, 1.4.5, 4.3). Second, a textual filtration process is conducted. This is a pragmatic strategy, developed by the researcher, whereby information regarding learning/instructional theories and characteristics of practice (Chapters Two & Three) is tested using the nine criteria. Theories/stances that comply are then extracted. Textual data is thus filtered through effectiveness criteria, culminating in the metamodel.</td></tr>
<tr><td colspan="3">Goal 2 - Case studies: evaluation of three learning events</td></tr>
<tr><td rowspan="3">Goal</td><td rowspan="3">Action goal:
(Using the metamodel as a tool to investigate effectiveness of applied learning products/events)</td><td>Methods</td></tr>
<tr><td>Quantitative methods:
Collection of quantitative survey data and limited statistical analysis.</td></tr>
<tr><td>Qualitative methods:
Investigation of qualitative, ethnographic, descriptive data from open-ended questionnaire surveys / observation / online observation / interviews.
Motivation / elaboration: As a direct participant in each case study, the researcher was able to use qualitative ethnographic methods, obtaining empirical data from natural settings, and investigating unanticipated avenues.</td></tr>
</table>

<table>
<tr><td colspan="3">Goal 3 - Determination of further information relating theory to instruction and learning in practice</td></tr>
<tr><td rowspan="2">Goals</td><td rowspan="2">Development goal
Interpretivist goal

(Further development and amplification of the metamodel, based on interpretation of phenomena from practice)</td><td>Methods</td></tr>
<tr><td>Inductive methods and qualitative methods:
Examination of the theories and characteristics being applied in practice, and induction of ways to implement them.
Qualitative inquiry into how the elements of the framework function in different kinds of learning.

Motivation / elaboration: The interpretive paradigm is characterized by subjectivity and the study of individual experience; it views theory as emergent from situations. This is indeed the case in this study, where the theoretical approach embodied in the metamodel is further informed by practice, tending to become a grounded theory.</td></tr>
</table>

This overview of the research design is followed by brief elaborations on development research and action research and an explanation of how each (or a variant) is used in this study.

1.7.2 Development research

If educational technologists wish to be socially responsible, they should undertake research that pursues development goals (Reeves, 2000). Socially responsible research in education is described by Reeves (1995; 2000) as *scientific research*, in that it:

- Queries the nature of reality, using processes that are verifiable,
- adheres to scientific norms, and
- is open to peer review.

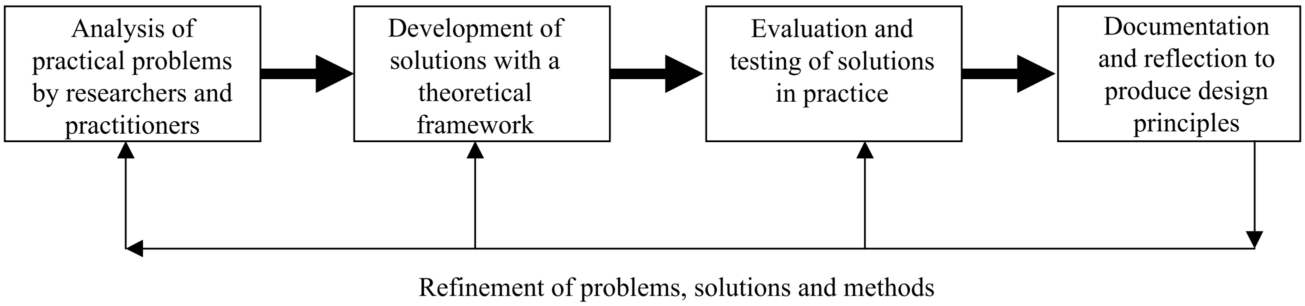
At the same time, it is a *social activity* which:

- Addresses problems that detract from quality of life for individuals and groups,
- with regard to learning and human development.

The overall purpose of development research is **to solve real problems, while simultaneously suggesting general design principles**. Development research in educational technology thus achieves its ultimate aim, if it results in the application by instructional practitioners of the proposed theoretical frameworks. Figure 1.1 sets out Reeves' (2000) cycle of phases in development research.

Figure 1.1 The development approach to research

(Reeves, 2000: 25)



1.7.3 Development research in this study

Development research, according to Reeves, requires a pragmatic epistemology that recognises the contributions of both researchers and educators (practitioners) to learning theory. This study supports that approach, in that it works from the base that instructor and designer are frequently one and the same, i.e. an instructor-designer, rather than an instructional designer. The research methods shown in the first and third parts of Table 1.2 are variants of development research. They correspond to a certain extent with the first phase portrayed in Figure 1.1, namely an *analysis of practical problems*, in that *Goal 1* addresses the instructional problems and benefits encountered under three major learning paradigms and corresponds closely to the second phase in the cycle, *development of solutions with a theoretical framework,* by its synthesis of an integrated framework termed the Hexa-C Metamodel. In respect of Reeves' third phase, *evaluation and testing of solutions in practice*, *Goal 3* in Table 2.1 aims precisely for this - using the framework to investigate existing learning events (i.e. learning events developed independently of the metamodel). The fourth phase of Figure 1.1, *documentation and reflection to produce design principles,* is partially implemented by the reflective inquiry into instruction and learning in practice (*Goal 3*), and by recommendations about ways of implementing the six Cs of the metamodel's framework in the design of instruction and learning events. Feedback from the evaluations informs further application of the metamodel; this is in line with Figure 1.1's feedback loop from the third and fourth phases back to the second.

1.7.4 Action research

Action research encompasses a variety of research and intervention methods, and simultaneously pursues *action outcomes* and *research outcomes* (Dick, Passfield, & Wildman, 1995). It has aspects which resemble field research, as well as aspects which function as an agent of change. In some forms *research is the main emphasis* and the action a secondary benefit. It can serve as an effective research process for investigative research and for evaluation. In action research the researcher is personally and closely involved with the participants.

Features of action research

According to Cohen, Manion and Morrison (2000) the focus of action research is on analysing and solving problems within their contexts. They define action research as a form of disciplined *self-reflective inquiry* in which an attempt is made to understand and reform practice, i.e. *small-scale intervention* in real-world operations. It is a move towards reflective practice that:

- Is designed to *bridge the gap* between research and practice;
- Combines *diagnosis* with reflection, focusing on practical issues; and
- Is done by practitioners on their own work.

The methodology of action research differs from conventional experimental research. It has developed a different set of principles and also has some characteristic differences from other qualitative methods (Dick, Passfield, & Wildman, 1995; Willis, 2000). It tends to be:

- *Cyclic*, as similar steps may recur;
- *Participative*, with clients, informants, and researcher being involved as partners, or at least as participants/team members, in the research process;
- *Qualitative,* dealing more with verbal aspects than with numbers;
- *Reflective*, since critical reflection upon the process and outcomes is a vital part of each cycle;
- A *responsive* approach, in that it responds in a flexible manner to the emerging needs of the situation. Each of the first four features above contributes to responsiveness:
  - The *cyclic* nature aids responsiveness and rigour, as early cycles contribute to the way the later cycles are conducted, which in turn challenge the interpretations of the earlier cycles.
  - The use of *qualitative* information increases responsiveness. The predominant use of natural language rather than Likert-scale ratings makes it easier for the *participating* informants to serve as co-researchers.
  - Critical *reflection* is a crucial step, as the researcher and others critique occurrences, then use this reflection in designing subsequent steps and events.

Hodgkinson (1998) - synthesizing the work of Bell (1987, cited in Hodgkinson, 1998), Wiersma (1991, cited in Hodgkinson, 1998), Zuber-Skerrit (1992), and Cohen & Manion (1994) - states that action research is:

- *Situational* - diagnosing and solving a problem within same context;
- *Collaborative* - involving practitioners and researchers as teams;
- *Participatory* - with team members themselves taking part in implementing research;
- *Emancipatory* - involving all participants as equals;
- *Self-evaluative* – modifying and evaluating on an ongoing basis to improve practice;
- *Practical* - aiming to produce improvements;
- *Interpretative* - incorporating social enquiry based on the views and interpretations of the participants;
- *Critical* - with participants acting as self-critical change agents;
- *Continuous* - as participants continue to literature, evaluate and improve practice; and
- Possibly *less rigorous in terms of design and methodology* than other educational research.

Zuber-Skerrit (1992) describes four processes undertaken repetetively by the action researcher in *a spiral of cycles*, namely: *plan, act, observe,* and *reflect.* This approach views action research as an ongoing process, rather than as an event.

1.7.5 Action research in this study

The research undertaken in this study is not action research in the cyclic form described by Zuber-Skerrit (1992), in which a practitioner-researcher undertakes an educational intervention that evolves over a period of time. Zuber-Skerrit's cyclic processes - plan, act, observe, reflect - are not holistically adhered to, since the courses investigated in Case Studies 2 and 3 were not specifically generated for this research. However, their observation and evaluation were intrinsically part of the study, and *reflection* upon them by their course leaders will be a direct result. The software analysed in Case Study 1 was developed, implemented, and revised by the researcher.

This research comprises two major processes, the second of which can be considered a *variant of action research.*

First, there is the derivation of a selected set of characteristics in order to concisely capture the current learning and instructional design theories which comply with the nine criteria in Section 1.4.4. The field is investigated by undertaking an extensive and intensive interpretive literature survey. The results of this survey are filtered through the criteria of 1.4.4 in order to extract appropriate theories, practices and characteristics. The resulting set of theories, practices and characteristics are, in turn, used to generate criteria which can be used in developing or evaluating learning environments.

Second, this set of characteristics is applied as a framework in three case studies to evaluate learning events to investigate whether and how they implemented the elements of the metamodel. The informants - course leaders and learners alike - contributed as participants. The processes are *participative*, *qualitative*, *reflective, collaborative*, *practical*, *interpretative* and *critical* - several of the features of action research listed in Section 1.7.4. Although limited quantitative investigations were undertaken, the data is primarily qualitative, since the small populations permitted rich open-ended investigation. The studies are characterized by intense *researcher-involvement*, which Willis (2000) views as a key feature of the current generation of action research. In each of the three case studies, the researcher had an involvement far closer than that of an external researcher, as is clear from the brief introductions to the case studies in Section 1.8.3.

If course leaders use the findings of the evaluations to refine their approaches to and delivery of their learning events, then the case study evaluations can be viewed as a *responsive form of action research*. Further responsive action would occur if course designers take cognisance of the selected theories and characteristics, and use them as recommended features when developing new course material and learning events/environments.

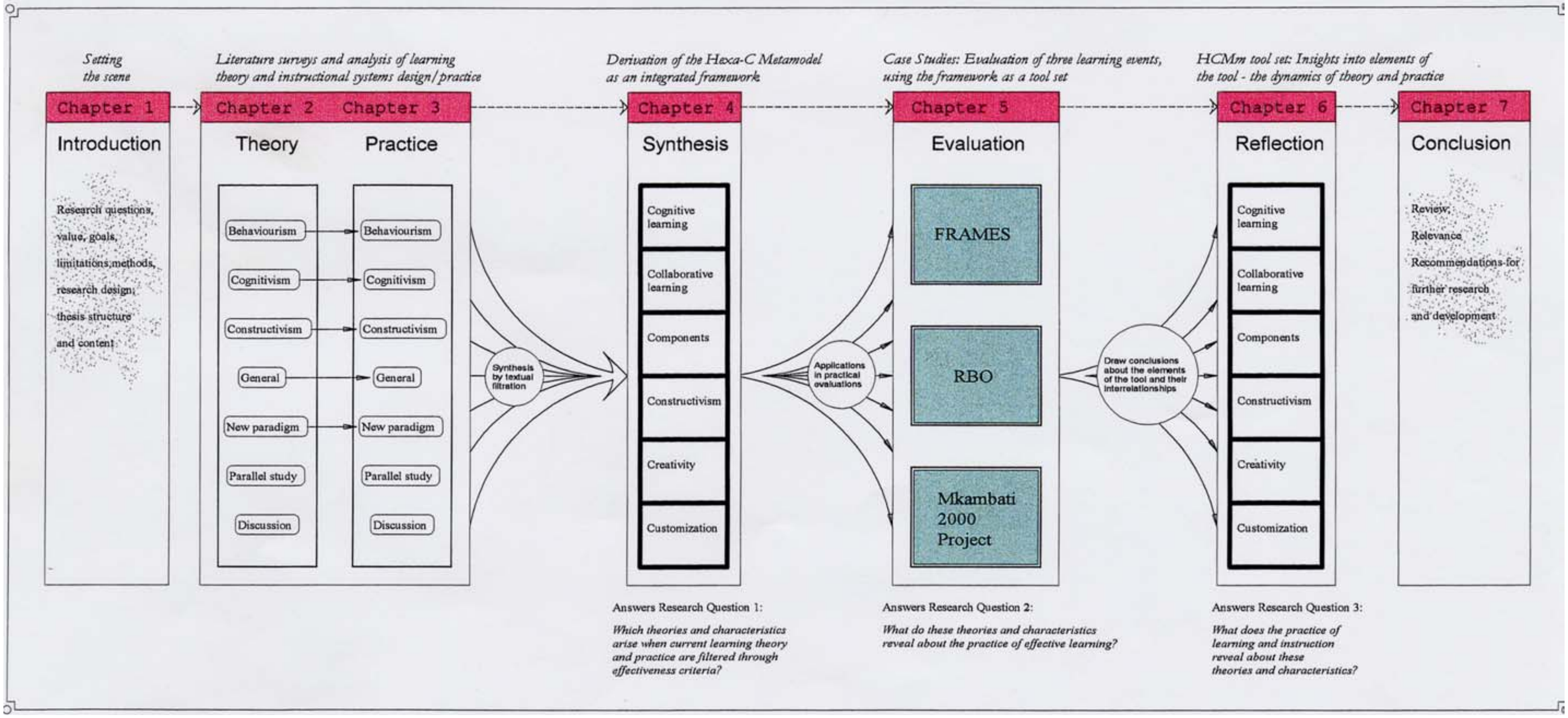
1.8 Structure and chapters of this thesis

Figure 1.2 in Section 1.8.1 sets out the structure of the dissertation and shows the inter-chapter relationships, while Figure 1.3 in Section 1.8.2 also portrays the content of the chapters, but as a linked diagram to show the development of the reasoning. Finally, Section 1.8.3 summarizes the material in each chapter.

1.8.1 Structure and interrelationships

The pull-out, Figure 1.2, shows the structure of the thesis and relationships between the chapters.

Figure 1.2 Structures of the thesis



1.8.2 Development of the reasoning

Figure 1.3 depicts the headers and content of Chapters Two to Seven in the form of linked activities, portraying the chain of reasoning.

Figure 1.3 Chain of reasoning

Chapter 2 *Theory*: Learning and instructional theory

Chapter 3 *Practice*: Learning and instructional systems design in practice

What does the extensive body of literature say about ***theory and practice****?*

Chapter 4 *Synthesis*: Towards a metamodel

How does the ***literature*** *(****theory and practice****) integrate to form a compact* ***framework to be used as a tool*** *for design and evaluation?*

Chapter 5 *Evaluation*: What the HCMm toolset reveals about three learning events - case studies

What does the ***toolset*** *indicate in the evaluations (from the perspective of learning theory) of three different* ***learning events****?*

Chapter 6 *Reflection*: What the case studies reveal about the HCMm toolset

What do the ***learning events*** *demonstrate about the* ***elements of the tool*** *and their* ***inter-relationships****, i.e. separately and compositely?*

(Note: this is the converse of Chapter Five.)

Chapter 7 *Conclusion*

What has been done and what should still be done?

1.8.3 Content of the chapters

Chapter One: Introduction

Chapter One introduces the study - its research questions, value, and delimitations; its research goals, methods, and overall research design. It culminates in a chapter overview, tracing how the researcher investigates various theories and practices of instruction and learning (from the cognitive family), with the aim of developing and applying a compact framework to facilitate the design of instruction for effective learning.

Chapters Two and Three: Extensive literature surveys

In Chapter Two the researcher takes an extensive overview of *theory* - studying philosophies and paradigms of learning and instruction - describing and discussing three current approaches, their evolution and interrelationships. Chapter Three covers the same ground as Chapter Two, but from an implementation perspective - overviewing *theory-into-practice*, i.e. practical applications of the paradigms, instructional design models, and practices within learning environments.

The literature sources surveyed incorporate a selection of classic works on the various instructional paradigms and learning practices overviewed, as well as publications by recognised experts in the field. As was stated in Section 1.4.3, some primary sources are the journals *Educational Technology, Educational Technology: Research and Development*, *Instructional Science*, and the *South African Journal of Higher Education*, as well as the web site of *IT Forum* (the online Instructional Technology Forum). Various textbooks, edited collections of articles, and refereed conference papers were also consulted.

Chapter Four: In which the metamodel is generated

Chapter Four sets out to answer the first research question posed in Chapter One by determining what theories and characteristics arise when contemporary learning theory, instructional design theory, and characteristics of effective practice are filtered through effectiveness criteria. The aim of the chapter is to develop a compact integrated synthesis of the current thinking. It does so by applying the selection criteria introduced in Section 1.4.4 to the theoretical and practical concepts of Chapters Two and Three, using the criteria as a filter to extract appropriate theories, stances and characteristics. The resulting framework, named the Hexa-C Metamodel, can be used as a design aid in the development of learning products and environments and is also valuable as a tool for evaluating such from the viewpoint of learning theory. The Hexa-C Metamodel is also compared and contrasted with Reigeluth's *New paradigm of instructional systems design* and the challenge of Duchastel's *Prolegomena to a theory of instructional design*, both mentioned in Section 1.4.3.

Chapter Five: Case Studies - a major chapter comprising three evaluationss

Three very different learning events are investigated - using the framework of the Hexa-C Metamodel as an evaluation tool - in order to address the second research question by determining what the selected theories and characteristics reveal about the practice of effective learning. The three learning events were chosen as case studies due to the researcher's close in-depth involvement in each.

1. ***Section 5A: Case Study One - the 1997/1998 evaluations of FRAMES***
   FRAMES is an interactive practice environment developed to help students in a complex section of COS101-S, a module in discrete mathematics for first-level computer science students at the University of South Africa. The researcher was the module lecturer (instructor), as well as the designer of FRAMES. A sample of 18 of the approximately 600 students annually (distance-learners) were surveyed in the evaluation.
2. Section *5B:* ***Case Study Two - the 1999 and 2000 presentations of RBO880***
   RBO880 is an online course for masters-level education students at the University of Pretoria, and is presented via a web-based classroom. The course presenter, who was also its designer, gave full support and co-operation in the process and the researcher participated as a student in the year 2000. The evaluation target comprised the 22 students of the 1999 and 2000 RBO880 presentations.
3. *Section* ***5C: Case Study Three - Mkambati 2000***
   The postgraduate course in Ecotourism at the University of Pretoria, incorporates fieldwork and a practical project as a major component. The researcher participated and assisted during the week-long field trip at the remote Mkambati Nature Reserve. Here too, the course lecturer was supportive of the research and keen to use its results for future refinements. The evaluation target consisted of the 12 students who participated in 'Mkambati 2000'.

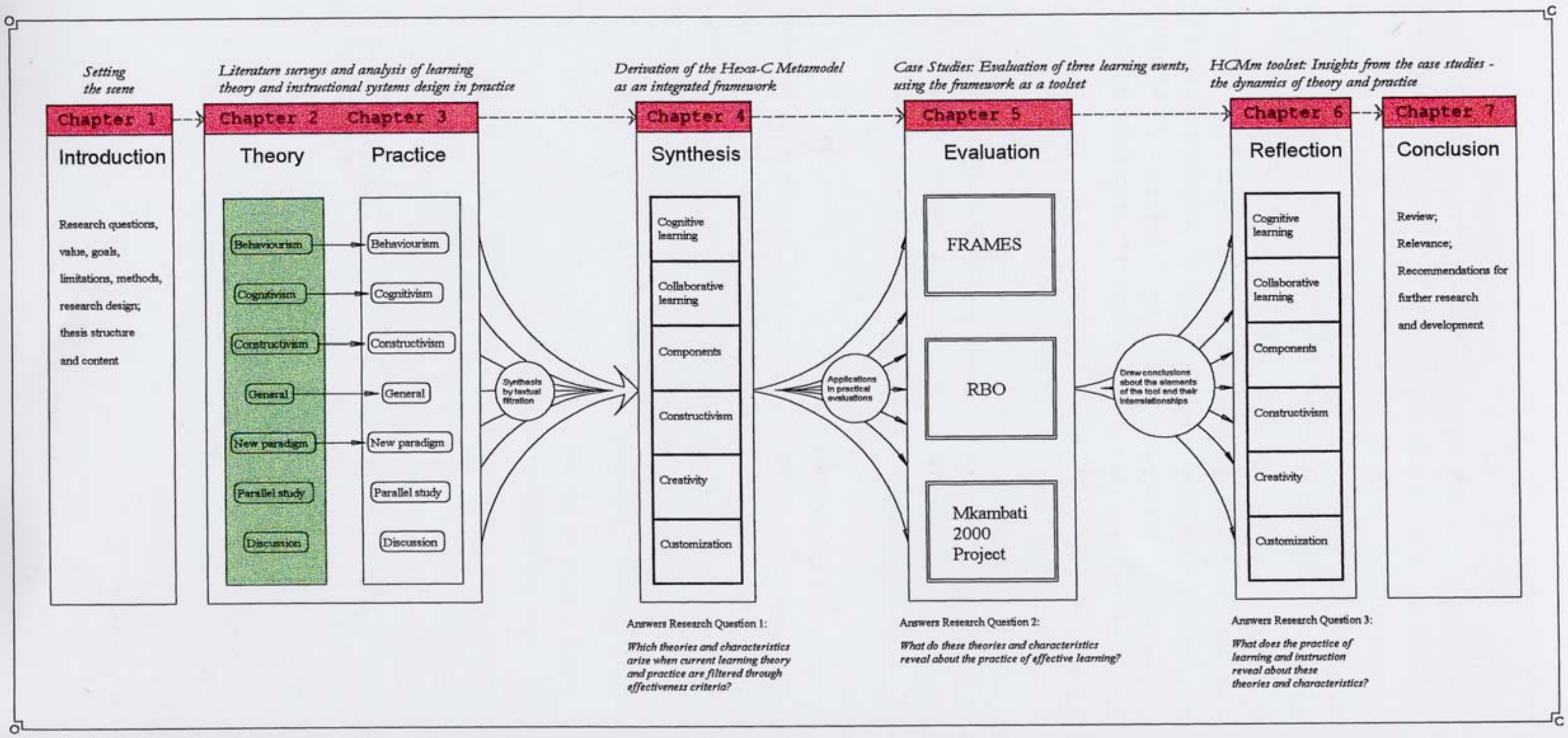
Chapter Six: Which reflects on elements of the metamodel

As already stated, Chapter Five used the metamodel as an investigative toolset for three evaluations. In response to the third research question, Chapter Six conversely uses the evaluations to elicit further information about the metamodel and its six elements, suggesting what the practice of learning and instruction reveals about the theories and characteristics embodied in the framework. The in-depth analysis resulted in extensive tabulations of information revealed about the elements of the framework - amplifying them, and indicating their dynamics and ways in which they can be implemented, as well as relationships between them.

Chapter Seven: Conclusion

This chapter briefly reviews what has been achieved, and suggests further research and development following on the findings of this study.

Structure of the thesis



Chapter Two

Theory

Learning and instructional theory

> *There is a revolution taking place in education, one that deals with the philosophy of how one teaches, of the relationship between teacher and student, of the way in which a classroom is structured, and the nature of the curriculum. At the heart is a powerful pedagogy, one that has been developing over the past hundred years. It embraces social issues, the culture of the classroom, life-long learning concerns, and perhaps both last and least, technology* (Norman & Spohrer, 1996:1).

2.1 Introduction

This chapter is a literature overview, investigating certain underlying philosophies and assumptions on formal learning. The perspectives overviewed and discussed fall into three main theoretical categories - the *behaviourist*, *cognitive*, and *constructivist* theories of learning, though there are areas of overlap. These three stances are examined in Sections 2.2, 2.3, and 2.4 respectively. Each is overviewed under various headings, setting out its background and ethos, key characteristics, and examples of related perspectives. The theories are addressed again in Chapter Three, which deals with practical applications of each in instructional systems design and learning environments.

The nature and mechanisms of learning, and varying perspectives and connotations of knowing have been objects of study since the time of the Ancient Greeks (Willis, 2000). Particularly since the 1960s, academics and practitioners in the Western World have paid attention to theories of learning and instruction with the aim of fostering effective learning. Instructional theory investigates methods of facilitating human learning and development to ‘help people learn better' (Reigeluth, 1999: ix).

There are *different kinds of learning* - momentary learning and temporary retention of knowledge; relevant, unintended learning occurring on a continual basis; acquisition of inert knowledge which serves no purpose until placed into a context; and formal learning. The latter is the focus of the theories of learning and instruction. And, there are *different kinds of knowledge* - basic facts and rudimentary skills; composite forms; well-structured knowledge; and knowledge in ill-structured domains (where content is not precisely specified and where there is not a single solution to a problem). A tendency in basic instruction is the pragmatic simplification of phenomena and associated isolation of aspects of a domain. Methods are proposed of communicating information so as to help learners apply knowledge, and to integrate learning and transfer it to complex domains.

2.2 Behaviourism

For the first half of the twentieth century, behavioural laws provided the foundation for most conceptions of learning. Behaviourism emphasizes **overt behaviour rather than covert mental operations**, and views learning as a **change in the behavioural dispositions** of an organism. Sections 2.2.1 and 2.2.2 describe early behaviourist interventions, in the form of stimulus-response shaping, and set out key characteristics of instruction and learning materials designed in the ethos of behaviorism. Certain other theories and approaches closely associated with the behaviourist stance are introduced in Sections 2.2.3 and 2.2.4, prior to the closing comments in 2.2.5.

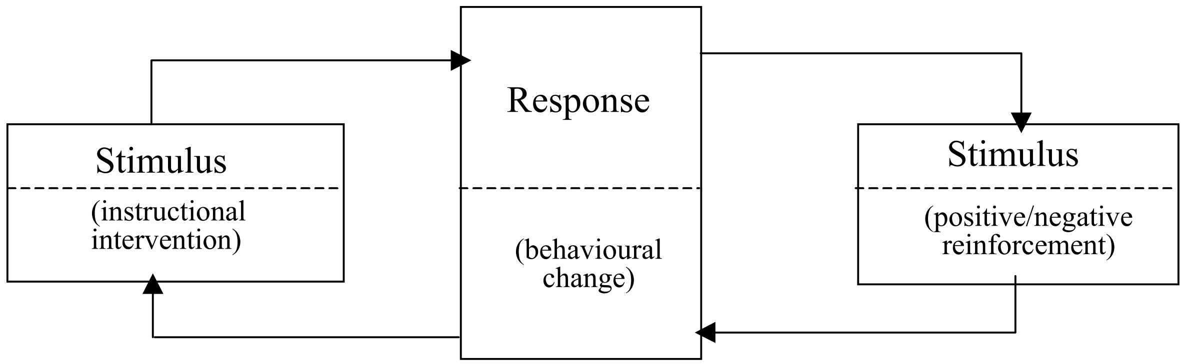
2.2.1 Background and ethos of behaviourist instructional theory

The dominant themes of early behaviourism were reflexes and their associated response terms, with the response being a physical event (Schoenfeld, 1993). Behaviourist learning theory suggests that learning outcomes are demonstrated by *observable measurable behaviour*. Instructional intervention, accompanied by selective reinforcement, is used to shape such learning. Skinner (1938), a classical protagonist of this theory, was reluctant to address the role of internal cognitive or conceptual activity as part of learning processes, since it is not observable.

Behaviourist learning is managed by stimuli from the environment, which result in responses from the learner. The *stimulus-response* pattern of behaviour is manifested in the learner's overt reactions. Correct responses should be rewarded with immediate reinforcement, leading to a *stimulus-response-reinforcement* paradigm. The principle of *operant conditioning* states that if the occurrence of an operant is followed by the presentation of a reinforcing stimulus, the strength is increased (Skinner, 1938). The initial stimulus is typically a question and the response is the learner's answer. Reinforcement, after the desired behaviour, may be an extrinsic reward or a positive comment.

This paradigm, depicted in Figure 2.1, encourages learners to perform actions which are rewarded. In pure Skinnerian theory, no reinforcement is given for an incorrect answer.

Figure 2.1 Stimulus-response-reinforcement



The theory was originally developed from experiments with animals, and was later applied to human learning by examining the effect of instructional intervention. It assumes frequent re-presentation, usually in increasing levels of difficulty. The behaviour of an organism is viewed as a function of external stimuli; and learning is viewed as the construction of a set of stimulus-response associations, induced by repetition and reinforcement. It avoids addressing internal cognitive processes, dealing rather with measurable behaviour and skills (O'Shea & Self, 1983; Venezky & Osin, 1991), hence the term 'behaviourism'. This contrasts with the cognitive perspective discussed in Section 2.3, where learning is viewed as the processing of information and storage within long term memory.

Response rate was initially used as the basic measure of behaviour, but was replaced by the more conventional accuracy and correctness measurements. A strictly Skinnerian view of response rate suggests that it is a variable primarily influenced by reinforcement, but precision teachers found that, in practice, learners' performances were strongly affected by their fluency in prerequisite skills, and that reinforcement procedures could not boost performance beyond certain ceilings. Further practice on the prerequisites or components helped the students achieve fluency on more advanced or composite performances, where fluency is defined as accuracy-plus-speed. Studies of automaticity in skills also support these conclusions (Binder, 1993). Automaticity is discussed further in 2.3.3.6.

2.2.2 Key characteristics of behaviourism

As behaviourism was increasingly implemented in educational practice, learning materials were explicitly designed in this ethos. Systematic design procedures became inherently behaviourist, as practices derived from systems theory were used to make instruction more effective, efficient, and relevant (Briggs & Wager, 1981; Braden, 1996) by designing *objectives*, *content*, *instructional methods*, and *learner-assessment procedures* in congruence with one another, as indicated in Table 2.1:

Table 2.1 Tightly coupled approach to elements of instruction		
Instructional objectives	**Content of instruction**	**Assessment procedures**
A set of observable, measurable objectives is defined early in the design process.	Instruction is focused on leading learners to achieve those objectives. Methods and instructional strategies are used which are appropriate for the objectives.	The objectives are used to create corresponding test items for learner-evaluation. Assessment is frequently developed prior to designing the actual instruction.

These traditional practices of instructional systems development (ISD) are characterized by Skinnerian psychology, and were especially manifest in programmed instruction (Dick, 1995). Reinforcement theory was used to create self-instructional material comprising frames of information followed by associated questions and answers. This approach was used as a basis for instructional design models, supplemented by the ideas of Robert Mager on objectives, Robert Glaser on criterion-referenced testing, and Robert Gagné's conditions of learning and events of instruction (Dick, 1995). The latter are introduced in 2.2.3.2 and 3.2.3.1 respectively. Instructional design models based on these principles are outlined in Chapter Three, Section 3.2.3.

2.2.3 Behaviourist instruction: associated concepts

Further work on instructional objectives and goals was undertaken by Gagné (1985) who made the assumption that there are **different kinds of instructional goals**, and that **different instructional strategies** are required for learners to more effectively and efficiently attain given kinds of learning.

2.2.3.1 Gagné's categories of learning outcomes

With the background of the above assumption, Gagné proposed a descriptive theory of knowledge defining five *categories of learning outcomes*. The Gagné-Briggs model of instruction describes five kinds of outcomes, each of which requires different instructional treatments and different *conditions of learning* for the outcome to occur (Aronson & Briggs, 1983; Gagné & Glaser, 1987). The learning categories are listed below and the associated conditions of learning are tabulated in 2.2.3.2.

Categories of learning outcomes:

1. Verbal information - the ability to acquire and recall factual knowledge.
2. Intellectual skills - the ability to do mental operations for problem solving and to relate principles to abstract concepts. There are five subordinate types:
   - Discrimination,
   - defined concept,
   - concrete concept,

- rule, and
- problem solving (application of rules).

3. Cognitive strategies - ability to plan and control thinking and problem solving.
4. Motor skills - ability to execute physical movements.
5. Attitudes - predisposition to a positive or negative approach towards a specific object.

2.2.3.2 Gagné's conditions of learning

The internal and external conditions of learning associated with the first, third, fourth, and fifth learning outcomes are listed in Table 2.2, while Table 2.3 shows the performances to be learned to demonstrate acquisition of the second category, namely the five intellectual skills.

Table 2.2 Conditions of learning for four of the five types of learning
(Aronson & Briggs, 1983:83)

Type of learning	Internal conditions	External conditions
Verbal information	Recall of context	Provision of new information in a wider context.
Cognitive strategy	Recall of rules and concepts	Successive presentation of novel problem situations without class of solution being specified; Demonstration by student of solution.
Motor skills	Component motor chains	Establishment of rules; Practice of total skill.
Attitudes	Recall of information and skills relevant to the required personal actions	Establishment of respect for source; Reward for personal action either by experience or by observation of respected person.

Table 2.3 Conditions of learning for intellectual skills
(Aronson & Briggs, 1983:84)

Type of intellectual skill	Performance
Discrimination	Differentiate between stimuli that differ in one or more dimension
Defined concept	Classify objects/events/states by description or definition
Concrete concept	Identify instances/examples of the defined concept
Rule	Demonstrate application of rule
Higher-order rule/problem solving	Generate new rules for problem solving

This work of Gagné and Briggs identifies aspects of human learning that are relevant for those engaged in instruction. Although the work is classified as learning theory, it contributes to instructional theory, in that once a learning outcome has been specified, instruction must be designed to achieve it. Gagné also proposed nine practical events of instruction as support for learning, which are outlined in 3.2.3.1 in Chapter Three.

2.2.4 Behaviourist learning theory: related perspectives

This section introduces philosophies and approaches that are related to the behaviourist instructional paradigm.

2.2.4.1 Objectivism

According to Duffy and Jonassen (1991a; 1991b), objectivists perceive learning and instruction as phenomena amenable to scientific analysis, so that the true nature of learning processes can be understood. Objectivism relates to the perception of *objective reality,* acknowledging a societally-accepted reality that exists apart from the learners. Cunningham (1991a; 1991b), Duffy and Jonassen (1991a; 1991b), and Jonassen (1991b), explain that from the viewpoint of objectivism:

- Reliable, stable knowledge exists about the world and concepts within it;
- The knowledge and skills which an educator requires his/her learners to know and be able to do, can be concretely structured and specified;
- Means can be determined to instill such knowledge and skills into learners effectively and efficiently; and
- The truth of beliefs is testable by reference to the facts.

In short, an objectivist epistemology defines knowledge as separate from knowing (Reeves and Reeves, 1997).

What is the epistemological significance for educators? It results in them aiming to bring different learners towards reality – to the same understanding of phenomena and acquisition of the same knowledge, aside from personal experience. The beliefs behind this instructional goal are that (Cunningham 1991a, 1991b; Duffy & Jonassen, 1991a, 1991b; Reeves & Reeves, 1997):

- Learners' thought processes can be analyzed and formed, producing meaning that is external to the subject, but determined by the real world;
- Instruction is the process of mapping entities and concepts onto learners, simplifying complexity in order to model the real world and its structures for learners;
- Learning consists of assimilating that objective reality. Learners are not encouraged to make their own interpretations - an instructor should interpret events/objects for them, and they should replicate the content and structure in their own thinking. Individuals' prior experience, understandings, beliefs, and human interpretation can lead to partial and biased understandings, which must be corrected via instruction; and
- Acquisition of learning can be measured by testing.

In empiricist and post-empiricist philosophies, the term 'objective' refers to statements that can be empirically shown to correspond with a reality external to individuals (Duffy, 1995). Much educational technology is based on the assumption that objective knowledge is universal knowledge. Hence many instructional design processes call for detailed pre-set instructional objectives, and criterion-referenced assessment in line with these objectives. Behaviourist instruction is generally accepted to be in line with objectivism.

2.2.4.2 Instructionism

Instructionist foundations (Jonassen, Campbell & Davidson, 1994; Hannafin *et al*, 1997) generally refer to well-defined and explicit learning aims and methods, where knowledge and skill requirements can be articulated, progress evaluated, and mastery demonstrated. This type of system often reflects a reductionist approach - a bottom-up, basics-first curriculum and teaching methods - see 2.2.4.3. Under instructionism learners tend to be passive recipients of instruction.

Information and skills training are presented on a need-to-know basis, since instructionists are pragmatists who tend to reconcile theoretically ideal situations with those optimally suited to available resources and constraints. Instructionism occurs in learning systems that offer modular, internally consistent, discrete subjects that are presented in fixed-duration class periods, for example, a traditional school. Epistemologically, it is associated with objectivist philosophy, and they are jointly termed the objectivist-instructionist approach.

2.2.4.3 Reductionism

Most sciences aim for reductionism - a simplification of their observations and explanations (Schoenveld, 1983), using models to represent complex phenomena. Research into learning theory aims to determine psychological foundations for the design of instruction. Reductionist instructional models entail a linear approach that studies components of a domain independently, progressing from basics to the more complex, rather than an holistic approach that investigates overall relationships and complex interactions between component parts in context. The behavioural approach epitomises reductionism. Cook (1993) points out a common thread within different forms of behaviourism, namely, explanations are kept as simple as possible.

A reservation expressed by Reigeluth (1991) suggests that the simplification inherent in reductionist stereotypes is open to *reductive bias*, whereby the decision about what to omit in a simplified representation is influenced by the values of the simplifier.

2.2.5 Comments on behaviourist instruction

Behaviourism emphasizes the design of instruction and the imparting of knowledge, with the goal of achieving effective and efficient learning - learning which is **demonstrated by behavioural changes**. The role of the instructor is paramount over the role of the learner, who tends to receive instruction in a passive manner. The processes are geared towards learners in general, and are not focused on individual learners. This approach may be appropriate for well-defined problems, but is ineffective in ill-structured domains.

Traditional instructional design models are built on deterministic foundations (Rowland, 1995) and are largely behaviourist. It is assumed that an optimal instructional design can be procured by analyzing a situation thoroughly to identify its definitive conditions and desired outcomes, and then applying the principles, prescriptions, and strategies for those conditions. Despite the structured and systematic nature of behaviourism, its shortcomings and rigidity began to evidence themselves, particularly as the school of cognitive science emerged. Some of the initial reservations on the part of cognitive theorists were due to the fact that much of the behaviourist research was carried out on animals (Cook, 1993).

The previous section pointed out that the behavioural approach makes use of reductionism. Subsequent learning theories, such as those to be introduced in Sections 2.3 and 2.4, incorporate a reluctance to reduce, due to their view that behaviourism neglects unique wholeness and personal experience, which is not in essence reducible (Schoenveld, 1993).

Nevertheless, certain aspects of behaviourism are proven to facilitate specific types of learning, and these should be subsumed, not replaced, by the new methodologies. Whatever learners do, and whatever changes may occur to their internal cognitive conditions, all these aspects are *de facto* manifested in their behaviour or by behavioural changes. Schoenveld (1983) urges against outright rejection of behaviourism, pointing out that the way it addresses human verbal behaviour can play a meaningful role, and is not the same as the way it sets out to shape reflexes and responses. Many behaviourists of the humanist-cognitive persuasion view verbal behaviour as a communicative channel, impacted by experience and thoughts, and shaped by the individual's socio-cultural environment. Both behaviourists and non-behaviourists would agree on the importance of cultural background and social origins in influencing learning.

This section has covered behaviourist learning and instructional theories. Theory-into-practice, i.e. specific principles and examples of behaviorist instructional systems and their development, are described in Chapter Three, Section 3.2.

2.3 Cognitivism

There has been a revolution in learning theory since the late 1960s, as the psychology of learning underwent a paradigm shift from the behavioural approach towards cognitive theories and models of learning which **focus on the mental processes involved in learning** (Winn, 1990; Jonassen 1991b). As research focused upon *how and why* learners learned, new theories of instruction and learning emerged. This section shows how the cognitive theoretical perspectives on learning differ from those favoured by the behaviourists. In Sections 2.3.1 and 2.3.2 the development of cognitivism is briefly explained, and certain branches and features are mentioned. Sections 2.3.3 and 2.3.4 describe some associated theories, concepts, and perspectives, leading up to a short discussion in Section 2.3.5 which concludes the discussion on cognitivism.

2.3.1 Background and ethos of cognitive learning theories

According to cognitive psychologists, learning is concerned less with behavioural responses - what learners do - and more with what learners know and how they acquire it. Changes in behaviour do occur, but are perceived as indirect, rather than direct, outcomes of learning. Cognitive theorists address aspects such as the **cognitive processes and higher-order thinking** exercised by learners as they attain new knowledge and skills, as well as the **internal mental representations** learners construct as they actively acquire information. Some of the earlier cognitive applications were developed in the field of artificial intelligence.

2.3.1.1 Ventures into artificial intelligence

As learning theory developed and educational technology began to change the paradigms of instruction, the shift away from behaviourism included contributions from the realm of computer science called artificial intelligence (AI). During the 1980s, sophisticated computerized knowledge representation techniques began to impact on education as AI practitioners sought to develop educational applications such as intelligent tutoring systems (ITSs) and intelligent computer-aided instruction (ICAI) systems, which incorporate:

- *Domain models* - knowledge bases holding the subject matter;
- *Student models* - that represent each learner and his/her state of knowledge; and
- *Tutoring modules* - which aim to bring the student's knowledge to the level of the domain knowledge, using strategies geared to each individual learner and the level of his/her knowledge.

The ultimate goal was to automate personalized instruction. The development of credible learner models proved intractable however, so the aims may have been over-ambitious (Squires, 1999).

ICAI and ITSs reside primarily in the domain of research, and have not been extensively used in authentic settings of education and training. Intelligent instruction stresses *meaningful interaction* between the learner and the system, and although the AI approach has not revolutionized education, the value of effective interaction has been increasingly recognised, and is being implemented in systems based on cognitive learning and constructivism.

2.3.1.2 Adaptive control of thought: Anderson's ACT model

Anderson (1983), a proponent of intelligent tutoring, distinguishes between two kinds of learning - *declarative knowledge,* comprising chunks of related factual units, and *procedural knowledge* which defines how to do things. The adaptive control of thought (ACT) model relates to declarative, factual knowledge. Anderson considers the units of human knowledge to be *propositions* comprising a subject and a predicate. Cognition is based on *productions*, which are rules comprising pairs of these propositions. Each production rule combines a condition proposition with an action proposition,

i.e. it is an *if ... then ...* production.

It is assumed that learners mentally compile their declarative knowledge into production rule format. When the condition (the *if* part) occurs, then the production is applicable and the action (the *then* part) is triggered, adding new elements to the learner's mental store.

2.3.2 Characteristics of the cognitive learning perspective

During the 1980s, intensive research was undertaken in the realm of cognitive development applied to human learning, and by the 1990s the behavioural approach was giving way to a cognitive paradigm. Particular attention is paid to fostering higher-order thinking skills within learners, as theorists posit that knowledge attainment comes not from mastering a hierarchy of skills, but from the use of critical thinking skills and the comprehension of fundamental concepts.

According to Reigeluth and Moore (1999), cognitive education comprises methods that help students in recall and recognition of knowledge, as well as developing their understanding and intellectual skills, including metacognition (see 2.3.4.3).

2.3.2.1 Key features of cognitive learning

Theories of cognitive science view learning as the execution of internal cognitive processes, such as thinking, remembering, conceptualization, application, and problem solving. Learning entails a reorganization of the brain's knowledge structures. In line with this approach, instruction is presented in ways that foster understanding, that develop metacognitive skills within learners, and optimize the internal processes of human cognition. Attention is paid to:

- *Knowledge representation* - Cognitive activity enables humans to construct and manipulate internal mental representations or models, variously called *schemata or schemas* (Inhelder & Piaget, 1958), *frames* (Minsky 1975), *mental models* (Merrill, Li and Jones, 1990a; 1990b; 1990c), and *propositions* (Anderson, 1983). A schema or frame is a mental structure with slots for objects and their properties and links to represent relationships.
- *The relationship between prior knowledge and new knowledge* - proposing that the latter is acquired by accretion into existing schemas - refining and restructuring them.
- *Cognitive strategies* - to improve the design of instruction, including: chunking, frames, concept maps, advance organisers, metaphors and analogies, rehearsal, imagery, and mnemonics. These strategies can be hybridised or combined by the instructor, and can also be independently generated by learners to enhance cognition. Research shows that students who consciously use such strategies become better able to reflect on their strategies, plan, and monitor their own learning, and check their progress toward goals (West, Farmer, & Wolff, 1991).
- *Active participation* by learners in the construction of their knowledge and development of skills.
- *Development of skills* that facilitate encoding, storing, and retrieval of information.

2.3.2.2 Bloom's taxonomy

Benjamin Bloom developed a taxonomy that is frequently used to categorize types of educational objectives for the cognitive domain, and which has become the standard for classifying educational objectives and activities (Reigeluth, 1999). Bloom's (1956) *Taxonomy of Educational Objectives* identifies six major types of learning, ordered from lowest to highest, of which the last three types, in particular, call for cognitive skills:

1. *Knowledge* - remembering previously learned material, the lowest level of learning;
2. *Comprehension* - grasping the meaning of material, the lowest level of understanding;
3. *Application* - using learned material in concrete situations;
4. *Analysis* - breaking down material into component parts to understand its structure;
5. *Synthesis* - putting parts together to form new wholes, i.e. creative behaviours; and
6. *Evaluation* - being able to judge the value of material for a given purpose; these are the highest learning outcomes in this cognitive hierarchy, because they contain elements of all other categories plus value judgments based on defined criteria.

2.3.2.3 Gagné-Merrill enterprise schemas

The transition from behaviourism to cognitivism spotlights the issue of instructional and learning goals. A foundation of traditional instructional design (ID) theory is identifying the goals of learning at the outset of the design process. Having identified the required learning outcomes and human performances, designers then determine what should be learned to attain those goals. Gagné and Merrill (1990), who had both worked on learning outcomes and objectives moved towards cognitivism by affirming the need for extension of these concepts to address situations where the instructional goal is a combination of several different objectives.

There are common features to Gagné's and Merrill's original models and theories. Both accept the effectiveness of working backwards from a goal to the required instructional events. The goal could involve identifying a category of instructional objectives, such as Gagné's (1985) verbal information or intellectual skill (see 2.2.3.1) or it could mean remembering, using or finding facts, concepts, procedures, or principles (Merrill, 1983, 1987) (see 2.3.3.3). For each single learning objective, the designer would prescribe the appropriate instructional conditions for learning. In practice, however, when instruction is considered comprehensively, *multiple objectives* frequently occur for which a linear sequence of single-objective instructional events or lessons may be unsatisfactory. Consequently, Gagné and Merrill sought a non-serial approach that would treat human performance at a higher level of abstraction. Facts and concepts must be learned and procedures acquired within the context of a more comprehensive activity, called an *enterprise,* which is far broader than a single-focus instructional unit. Required performances must be viewed in terms of their function and purpose within the activity as a whole. This is a more conceptual focus than that of the traditional behaviourist approach. The term, *enterprise schema*, is used by Gagné and Merrill to refer to the integration of multiple learning objectives as goals for enterprises. They perceive an enterprise schema as a cognitive representation, proposing that the *integrated goals* of various different enterprises are stored in human memory as mental models. A typical enterprise schema would reflect the purpose of the enterprise, the knowledge and skills needed to engage in it, and an indication of how and when each piece of knowledge or skill is related to the enterprise.

The distinguishing feature of an enterprise, therefore, in the context of learning and instructional theory, is the presence of integrated goals, embodying multiple objectives for a comprehensive, holistic learning activity.

2.3.3 Theories of cognitive instruction

Various theories emerged that postulate how human reasoning and learning occur.

2.3.3.1 Human problem solving: Newell and Simon theory

Pioneers in the analysis of human cognitive processes were researchers such as the Nobel laureate, Herbert Simon (Newell & Simon, 1972). Based on the computer, the AI community found new analogies for human cognitive processes. Newell and Simon postulated a theory that viewed man as a human information processing (HIP) system, when he/she is thinking and solving problems. They propose that the operation, both of the computer and the human brain, can be represented by a model of an information processing system.

Short-term memory (STM) is a sub-component of the major processor which receives all inputs and is the source of all outputs. It has a very small capacity and its information decays quickly. Long-term memory (LTM) selects certain information from STM for long-term encoding; STM in turn retrieves specific stored data from LTM and combines it with information input via the receptors at execution time. In short, the process of cognition comprises a series of operations:

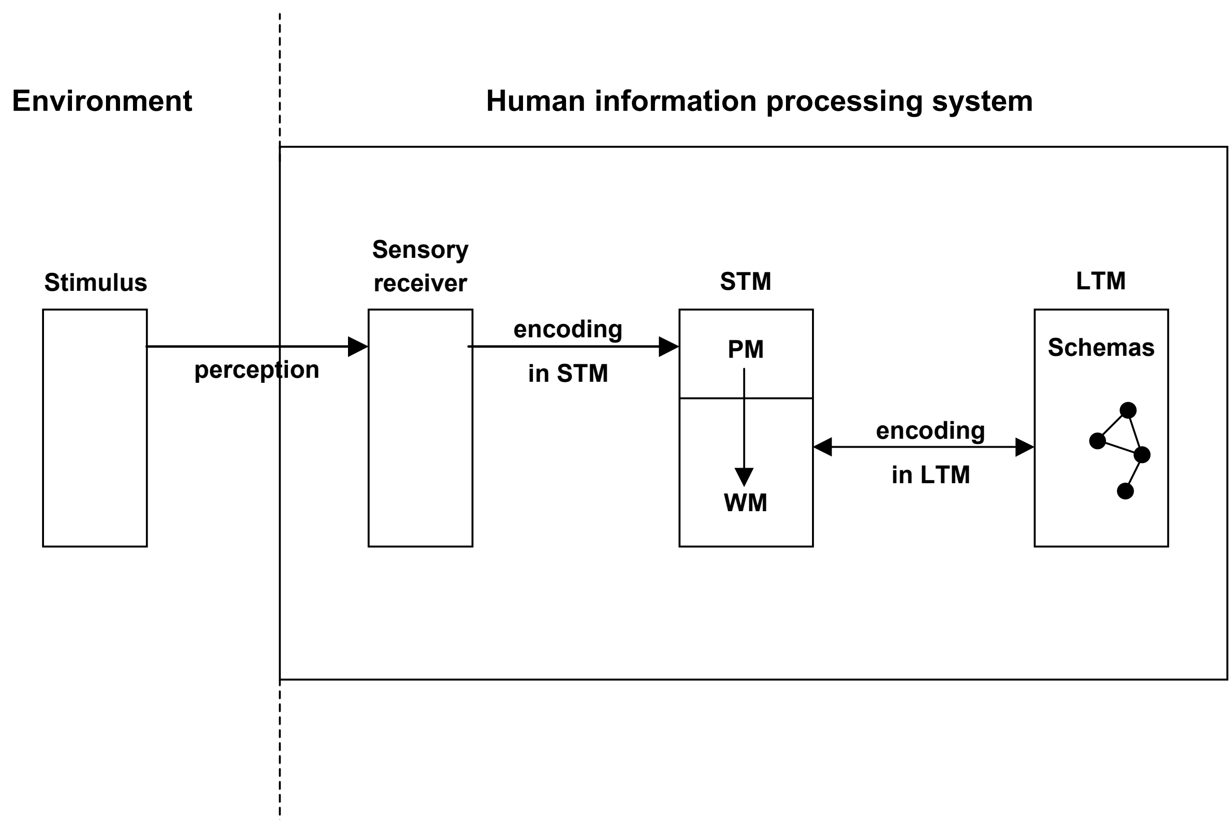
- Sensation from a stimulus,
- perception,
- encoding in STM,
- association,
- encoding in LTM, and
- retrieval.

In a discussion of cognitive science, Bednar *et al*, 1992 point out the objectivism (see 2.2.4.1) inherent in this analogy of the mind with a symbol-manipulating computer. Cognition is viewed as rule-based manipulation of symbols – with the symbols acquiring meaning when an external and independent reality is mapped onto them via learners' interaction with the world. The epistemology of this approach is that the external world is mind-independent, and the goal of instruction is to communicate a universally valid account to learners in an efficient and effective way, as occurs in computer processing.

2.3.3.2 Learning as human information processing

Gagné and Glaser (1987) build further on the Newell and Simon model and suggest an analogy between human learning and information processing. Input from external sources is received via human receptors. STM comprises primary memory (PM), where a small amount of information is stored for a limited time span (± 20 seconds), and working memory (WM), where the actual recognition and pattern-matching occurs between incoming information and stored information retrieved from LTM. Another function of WM is integration of the new material with existing knowledge structures in LTM, and a third function is rehearsal, the repetition process by which material in STM can be maintained for longer periods. The knowledge structures in LTM - comprising concepts and the associations between them - are referred to as schemata. Compositely, the schemata within LTM form cognitive networks, and once information is stored in LTM, it can be considered learned. Material that is learned has thus undergone sensory perception, reception, STM storage, processing in WM, and semantic encoding in LTM. The process is illustrated in Figure 2.2.

Figure 2.2 A human information processing system



2.3.3.3 Component display theory (CDT)

Component display theory (Merrill, 1983; 1987) is founded on Gagné's principal assumption that there are different kinds of learning outcomes and that different kinds of internal and external conditions are necessary to promote each kind of knowledge- or skill acquisition. In other words, the conditions of learning should match the desired learning outcomes. Component display theory (CDT) represents a transition towards cognitivism, and should lie between behavioural and cognitive learning on a continuum of learning theories, due to its emphasis on conceptual understanding.

CDT is based on relationships between the *content* to be taught and the type of *performance* required. The instruction comprises a set of components, and categorizes instructional outcomes on a two-dimensional matrix according to the type of content and performance.

The four types of content are: fact, concept, procedure, and principle; these describe the different types of knowledge that comprise a domain to be learned. *Facts* are arbitrary associated pieces of unitary information. *Concepts* are groups of objects, events or symbols sharing some common characteristic identified by a similar class name. A *procedure* is an ordered sequence of steps to accomplish some goal or solve a particular class of problem. *Principles* are correlational or cause-and-effect relationships that interpret or predict events or circumstances.

The three performance levels are: remember, use and find. *Remember* is the performance that requires a student to recognize, then reproduce, an item of information. *Use* requires a student to apply some abstraction or approach, and *find* requires derivation or synthesis of a new abstraction or independent process execution.

Each desired learning objective is related to the appropriate type of content and to the desired outcome in terms of performance, resulting in an *instructional component* that can be positioned in a cell on the performance-content grid. This is discussed further in Section 3.3.3.1 in Chapter Three.

Position and role of component display theory

As already indicated, CDT straddles the divide between behavioural and cognitive learning. It is behavioural in its foundation on learning objectives and on Gagné's conditions of learning. Reigeluth (1983) suggests that the three levels - remember, use and find - correspond closely to three of Gagné's cognitive domains, namely: verbal information, intellectual skills and cognitive strategies, respectively. Reigeluth (1989) also points out how CDT draws from various learning theories - cognitive tactics such as mnemonics and analogies, as well as behavioural strategies such as practice with reinforcement and shaping. In this study, CDT has been placed under cognitive learning rather behaviourism, because of its role in leading towards ID_2, to be described in 2.3.3.4.

It is notable that in the context of the *new paradigm of instructional theories*, to be discussed in Section 3.6, Reigeluth and Squire (1998) emphasize that the new should include, rather than replace, predominant paradigms. Referring particularly to CDT - fifteen years after its original publication - they advocate that its basic methods be incorporated within broader state-of-the-art theories.

2.3.3.4 The second generation paradigm (ID_2)

In 1990 Merrill, Li and Jones (1990a; 1990b; 1990c) recognized that most of the then instructional-design theory and instructional products were dated by over 20 years and rooted in behavioural psychology, based largely on the initial work of Robert Gagné. Gagné's later work incorporated ideas from cognitive psychology (Gagné 1985; Gagné & Glaser, 1987), and tended more to holistic approaches (Section 2.3.2.3; Gagné & Merrill, 1990), but the essence remained the same. From a cognitive viewpoint Merrill, Li and Jones pointed out limitations of so-called *first generation instructional design*:

- Content analysis focuses on knowledge and skill components in isolation, rather than on the integrated, cohesive wholes necessary for understanding complex and dynamic phenomena.
- Prescriptions for pedagogic strategy and course organization are superficial or absent, reducing the actual classroom utility.
- Theories of instructional design are essentially closed systems, not easily able to accommodate new knowledge. In particular, there are no means for incorporating new and detailed expertise from research about learning and its application to the design process.
- Each design phase is performed independently, and there is little integration of phases.
- Instruction is frequently passive rather than interactive, leading to little mental effort or effective retention on the part of learners.
- Design and development of instructional systems are inefficient, labour-intensive processes, with a development/delivery ratio exceeding 200:1, partly due to intensive computer programming. The impact of computerization on education may actually have decreased productivity.

In view of these shortcomings, Merrill, Li and Jones (1990a; 1990b; 1990c) set out to produce a conceptual methodology to guide the design and development of high quality, interactive, technology-based instructional materials. It was named *second generation instructional design* (ID_2) and was specifically intended to analyze, represent and guide instructional development, so as to:

- Teach integrated sets of knowledge and skills;
- produce flexible prescriptions for selecting interactive instructional strategies; and
- be an open system that could incorporate new knowledge about teaching and learning and apply it in the design process.

***The assumptions of* ID$_2$**

ID$_2$ has a cognitive foundation, based on the belief that learning results in the organization of memory into cognitive mental models. It retains Gagné's assumption that different conditions are required to promote different learning outcomes, but extended by the view that learned performances result from organised and elaborated mental models. Construction of mental models and retrieval of information are facilitated by instruction that explictly organises and elaborates the knowledge being taught. The architecture of ID$_2$ is described in 3.3.3.4 in Chapter Three.

2.3.3.5 Instructional transaction theory (ITT):

The theoretical assumptions and proposals of ID$_2$ led to instructional transaction theory (Merrill, 1996a; 1997), developed to automate instructional design. It proposes that instructional systems be generated using algorithmic computer programs instead of frame-based authoring systems.

The purpose of instructional transaction theory (ITT) is to derive theory and a methodology to facilitate automation of much of the labour-intensive instructional development process by setting up a content-independent shell. Representing knowledge as data enables the construction of a general-purpose inference engine to manipulate and present the knowledge of a variety of domains using its in-built instructional strategies. The architecture and knowledge representation structures of ITT are described in 3.3.3.5 in Chapter Three.

2.3.3.6 Automaticity

Automaticity is a further concept that belongs within both behaviourism and cognitivism. It is a two-fold capability, relating to the ability to perform a skill 'unconsciously' with speed and accuracy, while simultaneously consciously executing other brain operations (Bloom, 1986).

Bloom's (1956) Taxonomy identifies various types of knowledge and skills in the cognitive domain - see 2.3.2.2. The categories of motor skills and intellectual skills (such as prowess in music/sport and accuracy in mathematical reasoning, respectively) entail much practice and training to attain proficiency. This is termed *overlearning*, and leads to the *automaticity in subskills* which is required to achieve top-level performance. Such automaticity reaches a level where these basic skills can be used without conscious attention, while devoting the conscious mind and cognitive processing to something else, i.e. two different processes executed simultaneously. Once a skill reaches the level of automaticity, it requires frequent use but little special practice to maintain it, and it can be used with economy of effort while other conscious functions occur simultaneously (Bloom, 1986).

2.3.4 Cognitive learning theory: related perspectives

Various stances and concepts are closely associated with cognitive learning. Complexity theory promotes the connection between the cognitive and affective domains. Further concepts from the cognitive family, briefly overviewed in this section, are transfer, metacognition, cognitive flexibility theory, and objectivism. Some aspects are new; others were mentioned in Section 2.2.4 and are re-visited here, since they are associated with cognitivism as well as behaviourism.

2.3.4.1 Complexity theory: integrating the affective with the cognitive

In any system, complexities occur due to interactions between its component parts. Addressing this phenomenon, complexity theory attempts to capture the particular complexities of nonlinear phenomena. Since learning and thinking are dynamic processes with non-linearity as an inherent characteristic, Tennyson and Nielsen (1998) apply complexity theory to learning theory as a foundation for ID theory, in particular exploring relationships between the cognitive and affective domains.

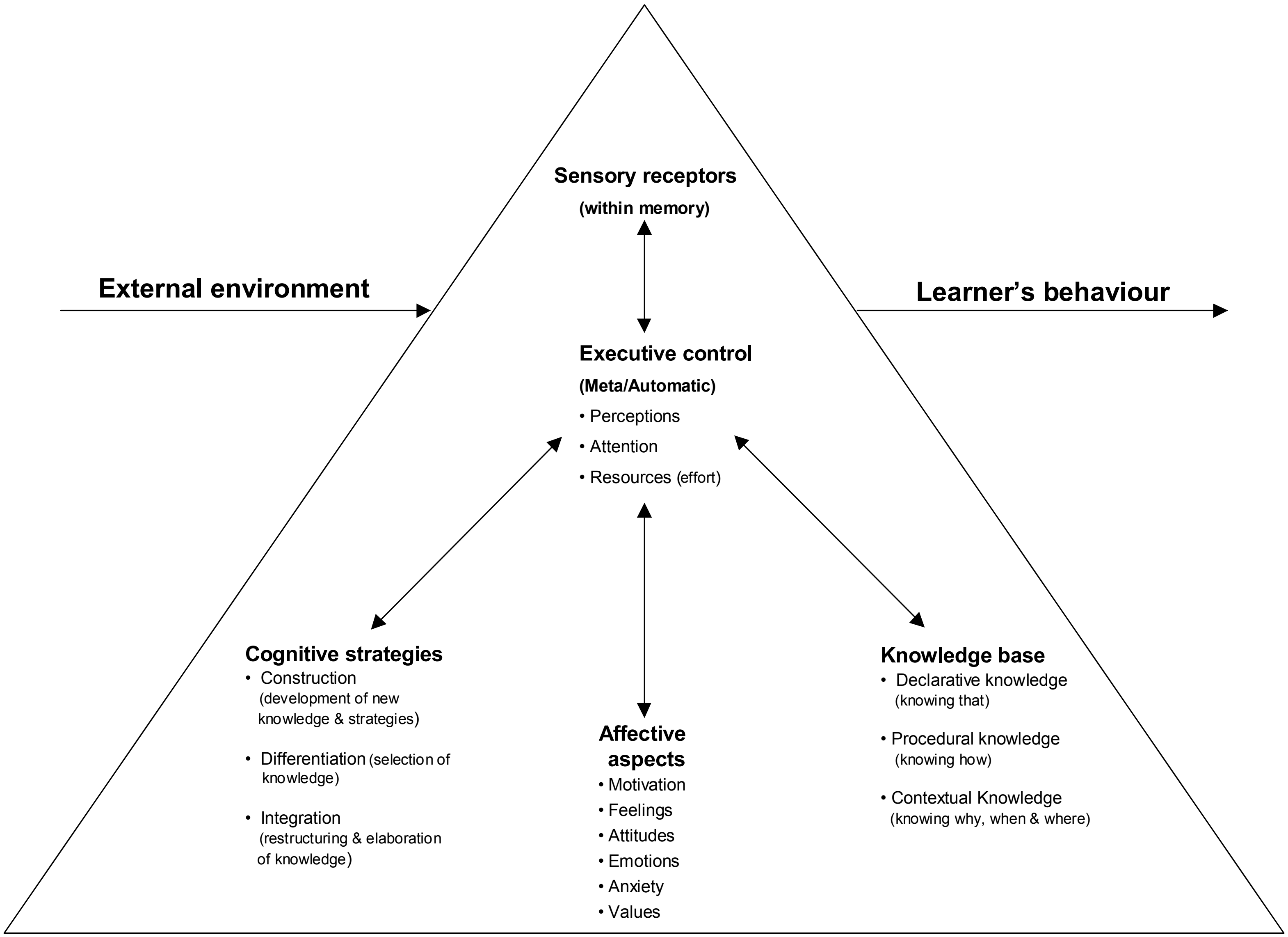
Unlike the linear models of human information processing theory (see 2.3.3.1, 2.3.3.2, and Figure 2.2), complexity theory addresses situations with non-linear conditions where learning outcomes are difficult to predict. Some of the factors that create nonlinear conditions in learning are issues such as *time, anxiety,* and *environmental* variables.

The three guidelines used for the interactive learning model are that it should contain:

1. Affective elements;
2. Linear and non-linear elements of cognition; and
3. Interaction of content knowledge and cognitive strategies for higher order cognitive processes such as problem solving, decision making, trouble shooting, and creativity.

Figure 2.3 shows an instructional theory model from the perspective of complexity theory. In contrast to the linear model of human information processing of Figure 2.2, it has two primary information sources - external and internal. The information from the external source is similar to the input to Figure 2.2 and is similarly received by sensory receptors. Internal information is the result of active interaction between the various subsystems and the executive control subsystem. It is a highly dynamic, interactive system with constant integration of its subsystems.

Figure 2.3 Interactive learning model
(Tennyson and Nielsen, 1998:9)



The *affective component* is most important, since a main goal of the theory is to demonstrate integration of the affective with the cognitive, with the intention of influencing instructional practice and learning environments. The affective domain is highly complex, and includes personality variables such as motivation, feelings, attitudes, emotions, anxiety, and values. It interfaces directly with the executive control, which in turn, interacts with the *knowledge base*, the store of previously acquired information, to which new knowledge will be related. Thus it has a far-reaching influence on the whole system, since the learner's values and feelings influence the acquisition of knowledge, while motivation impacts on aspects such as attitude and attention. Cognitive strategies are used to develop new knowledge and skills, and to selectively differentiate and integrate new learning so as to elaborate existing knowledge. Using concepts from chaos theory to extend their work in cognitive complexity, Tennyson and Nielsen (1998) include three primary cognitive abilities in the *cognitive strategies component*, namely: differentiation, integration, and construction to support learning.

Learning is not viewed as a linear sequence from sensory to STM to LTM, but as a flexible and adaptable system depending on active cognitive processing of the various interactive components and the external environment.

2.3.4.2 Transfer

Transfer (Osman & Hannafin, 1992) relates to the application of a trained strategy within a different context. When learners demonstrate transfer by taking knowledge and skills learned in one domain and using them in another situation, it demonstrates true learning. For learners to acquire independence and self-sufficiency, they need to transfer strategies to other learning tasks, problems, or circumstances.

If the circumstances are similar, it is called *near transfer*; where conditions are dissimilar, yet the training has applicability, reference is made to *far transfer*. Another classification describes *low-road transfer* - emphasizing detail and low-level knowledge, and *high-road transfer* - relating to higher-order, relational and conceptual knowledge.

2.3.4.3 Metacognition

Metacognition - thinking about thinking - is the ability of learners to plan, monitor, and control their own cognitive processes and performance, and to select learning strategies for themselves (Winn, 1990; Osman & Hannafin, 1992). It refers to awareness of one's own knowledge and the ability to understand and manipulate cognitive processes. Psychologically it is rooted in the human information processing models, which characterize the mind as an inference machine that uses existing knowledge to interpret and restructure new information. A related concept is *metamemory* -

learners' knowledge of their strategic behaviours and memory systems. Research has demonstrated a relationship between metamemory and successful performance. The correlations are generally higher for procedural than for declarative knowledge, and good performance is more related to metamemory monitoring strategies than to simple metamemory knowledge.

A further relevant concept is *self-regulation*, which refers to continuous metacognitive adjustments by learners during the learning process, particularly in response to errors.

Cognitive practitioners advocate that higher-order thinking skills and cognitive strategies should be explicitly incorporated into learning and instructional materials, along with the subject matter (West, Farmer, & Wolff, 1991). When learners personalize this and use cognitive strategies naturally, the practice facilitates transfer into other domains.

2.3.4.4 Cognitive flexibility theory

Cognitive science views learning as a reorganization of internal knowledge structures, i.e. the creation of schemata or mental models, and the retrieval of information from these structures. Cognitive flexibility theory (Spiro, Feltovitch, & Coulson, 1994) is a variant largely concerned with using knowledge and skills beyond their initial learning situation. It emphasizes presentation of information from multiple perspectives and the use of case studies to illustrate diverse examples. Cognitive flexibility stresses the assembly of mental schemata more than their retrieval. The theory is strongly related to constructivism and the importance of knowledge construction (Section 2.4). The four primary principles of the theory are:

1. Learning activities must provide *multiple representations of content*.
2. Instructional materials should *avoid oversimplifying* the content domain and should support context-dependent knowledge.
3. Instruction should be *case-based* and emphasize knowledge construction, rather than transmission of information.
4. Knowledge sources should be highly *interconnected*, rather than compartmentalized.

2.3.4.5 Objectivism

Objectivism, which is closely allied to behaviourism, is defined in 2.2.4.1 and its implications for instruction are set out. Cognitive learning can also be construed as an objectivist approach, since it simplifies complexity in learning and instruction in order to model the real world and its structures for presentation to learners, striving to lead them towards a **common understanding of phenomena**.

The objectivist epistemology also underlies much of cognitive psychology, particularly the cognitive theories which propose that understanding is represented by knowledge structures or schemata such as production rules, or frames and slots (Duffy & Jonassen, 1991a). Cunningham (1991b) considers Merrill's instructional models as embodiments of the objectivist perspective, since they adopt the view that knowledge can be represented outside the mind, and that there is a correspondence between external knowledge and internal representations.

2.3.5 Discussion on cognitivism and its development

This section has overviewed cognitive learning and instructional theories. Cognitive theory-into-practice, i.e. specific principles and examples of cognitive instructional design models and instructional practice are described in Chapter Three.

The early cognitive position was characterized by instructor-centricity, relying heavily on the terms, *instruction* and *student*. Viewing cognitive trends in the mid 1990s, Jonassen, Campbell and Davidson (1994) describe how intelligence and cognitive activity are distributed between *learners* and their supporting *environment* - a distinct paradigm shift. The medium is part of this learning context, which in turn is part of a larger social context. This is an advance on the unsupported cognitive processes depicted in the basic human information processing models of the 1970s up to the mid-1980s. Moreover, students are no longer viewed merely as knowers who store and remember information, but as true learners - independent thinkers who process information meaningfully and relate it to their prior knowledge (Chien Sing 1999). The teacher becomes more of a *facilitator*, one who 'is on the learner's side' (Reigeluth, 1991:36).

These philosophies go hand-in-hand with the emergence of true constructivist learning environments in the mid-1990s. Constructivism, introduced and investigated in Section 2.4, has sometimes been termed an implementation of cognitivism. Although it is related, it is far broader than this description would imply. It diversifies and occupies its own territory, both in terms of theory and the practice of learning.

2.4 Constructivism

Constructivism originates from Bruner's theoretical framework for instruction (1967; 1994). The framework is based on the study of cognition and postulates that learning is an active process in which learners construct new ideas or concepts based upon their past and current knowledge. Bruner taught mathematical concepts to children, providing them with materials to build, visualize, and measure physical patterns or constructions. By varying sizes and shapes, list of equations developed, 'a product of the child's own constructing' (Bruner, 1967:62). Next Bruner would teach the same concept by using a different model/image, calling this dual approach 'multiple embodiments'. Finally children 'wean themselves from the perceptual embodiments to the symbolic notation' (Bruner, 1967:63). Bruner suggests that instruction is not a matter of getting learners to commit results to mind:

> *Rather, it is to teach him to participate in the process that makes possible the establishment of knowledge. ... Knowing is a process, not a product* (Bruner, 1967:72).

Constructivism is a philosophy that emphasizes the development by learners of cognitive structures based on their previous knowledge and their experiences in learning environments (Reeves & Reeves, 1997). In Bruner's framework **learning is an active process, rather than being the generation of products**. It is a process whereby learners select and transform information, construct hypotheses, and make decisions - using their cognitive structures such as schemas and mental models to provide organizing structures that help them to discover principles and go beyond the given information.

One viewpoint positions constructivism as an experiential form of the cognitive sciences; another sees it as separate from cognitivism, due to the view of cognitive learning as an implementation of objectivity which is considered by holders of the latter standpoint as the antithesis of constructivism. Bednar *et al* (1992) hold the first opinion, referring to *the constructivist view of cognition*, as does Wilson (1999) who terms constructivism a *version of cognitivism*. Likewise, Greeno, Collins and Resnick's (1996) cognitive/rationalist view incorporates a *constructivist programme* (see Section 2.7.2).

In Sections 2.4.1 and 2.4.2 the development of constructivism is explained and key characteristics are introduced. Section 2.4.3 addresses some of the contentious issues surrounding constructivism, while Section 2.4.4 briefly overviews radical constructivism. Related perspectives and concepts, as well as associated theories, are described in Section 2.4.5, before concluding with a short discussion on constructivist learning in Section 2.4.6.

2.4.1 Background and ethos of constructivist learning theories

Why the constructivist (r)evolution?

Learning theory has undergone a major revolution since the 1960s, as the psychology of learning underwent a paradigm shift from the behavioural approach towards cognitive theories and models of learning (Jonassen, 1991b). Jonassen considers the shift incomplete - acceptance of cognitivism was inconsistent, and learning behaviour remained a prime focus. There is a need for a mentalistic perspective, application of cognitive instructional sciences, a more holistic approach to learner interactions, and a less reductionist form of analysis. Could it be that cognitive psychology did not provide a sufficient paradigm shift - that it does not adequately conceptualize the mental state and requirements of learners? If so, a further shift is required in instructional and learning theories, and constructivism is perceived as the new philosophical paradigm to advance learning and address the issue of learners' inadequate problem-solving skills.

Constructivist values

A constructivist perspective entails a shift in values (Lebow, 1993), since the traditional values of educational technology, namely: replicability, reliability, communication, and control, differ considerably from the seven primary constructivist values of: *collaboration, personal autonomy, generativity, reflectivity, active engagement, personal relevance, and pluralism*. During the early 1990s, the constructivist philosophy took the educational world by storm as authors published harsh criticism of the prevailing paradigms, and proposed constructivism as the panacea.

What constructivism is

Constructivism (Cunningham, 1991a; 1991b; Duffy& Jonassen, 1991a; Jonassen 1991a; 1991b) relates to learners constructing their own knowledge, in the sense of **constructing their own reality, using experience or interpretation of personal experience**. Constructivism opposes the objectivist viewpoint set out in 2.2.4.1. Although it does not deny the qualified existence of external reality; it proposes that individuals construct their own reality through their unique set of experiences, using the mind as a filter to interpret events, objectives, and perspectives. Each learner compiles a knowledge base that is personal and individualistic. There is no single universal reality or objective entity.

What constructivists believe about learning

Constructivists believe that individuals are intrinsically motivated to seek information and exploit it to facilitate learning (Hannafin, 1992). Learners interpret objects and events in the context of experience, forming opinions and tentative conclusions. Mental representations change and develop; progressive refinements occur, so that **understanding is a process not an event.** Constructivists believe in a *zone of proximal development* - a condition of cognitive readiness that must be in place for learning to occur, lack of which hinders learning. Finally, constructivism promotes *reflection* and *reconstruction* as more important than activities that promote mere assimilation of knowledge.

How personal is knowledge construction?

The way knowledge is constructed is a function of prior experiences, mental structures, and the belief- and value structure one uses to create meaning and interpret experience. The role of mental activity in learning is vital, and comprehension is considered in relation to a learner's interactions with the environment (Chien Sing, 1999). Learning differs from one individual to another.

Jonassen, however, urges caution with regard to inferences such as 'we each construct a unique reality' (Jonassen,1994:35). Rather, each learner's knowledge is a function of individual experiences, beliefs, and biases, i.e. perceptions of the same reality may vary. Constructivists also postulate that much of reality is reinforced by shared beliefs, termed social negotiation of meaning, and therefore make extensive use of collaborative efforts.

2.4.2 Key characteristics of the constructivist learning perspective

Constructivist learning emphasizes active learning over direct instruction; integrated assessment rather than criterion-based evaluation; learner-centredness and self-regulation; cognitive activity within complex authentic problems; and highly contextualized learning activities.

2.4.2.1 General features and characteristics

Constructivism has certain key characteristics, such as active participation by learners, recognition of complexity, multiple perspectives, and real-world contexts. It also holds particular stances on issues such as objectives, entry behaviours, assessment and errors (Cunningham, 1991a; 1991b; Dick, 1991; Jonassen, 1991a; 1991b; 1994; Duffy & Jonassen, 1991a, 1991b; Bednar *et al,* 1992; Savery & Duffy, 1995; Dodge, 1996; Siegel & Kirkley, 1997; Willis, 1998; Chien Sing, 1999):

- *Active participation*

  Rapid change, a feature of life since the latter part of the 20th century, requires adaptability, flexibility, and problem-solving skills. To succeed in this climate, learners should undertake self-initiated exploration of resources and active participation with learning content, activities, and environment. Instructors and teachers should not focus merely on the **delivery of information to passive learners**, deciding what and how they should learn. Instead, the emphasis should be on **tasks, experiential activities, and alternative paths** - stimulating cognitive growth and supporting learners by providing rich learning environments in which they can interact contextually, explore, and extract relevant information.

- *Complexity and cognitive conflict*
  The constructivist school posits that the objectivist approach - whether cognitively or behaviourally based - of reducing complexity, may be misrepresenting the thinking and mental processing required by such tasks. Since much academic content has inherent complexity, attempts to simplify learning for the sake of efficiency and effectiveness may actually restrict mental processing, rather than engaging and enhancing it. Chien Sing (1999) proposes that exposure to the real environment (albeit via computer-mediation) provides opportunities to address *cognitive conflict* or puzzlement, as learners reduce complexity themselves by interaction, inquiry, and exploration. Information should be meaningfully processed, related to prior information, and applied to new situations beyond the immediate assignments or examinations. The accommodation of new knowledge within existing mental models is a step towards resolution of such conflict and confusion. According to Savery and Duffy (1995), cognitive conflict is a stimulus for learning. Perkins (1991b) suggests ways of handling the learner-frustration engendered by *cognitive complexity* (see Section 2.4.3).
- *Multiple perspectives*
  Learners must be presented with various perspectives on an issue and different approaches to the same subject matter, so as to be able to evaluate alternative understandings.
- *Real world context*
  Real-world tasks are different from well-structured single-solution textbook problems; they do not have well-defined, predetermined solutions such as those encountered in objectivist learning. A tenet of constructivist learning is to identify where the skills will be used and to situate learning experiences in a relevant context. Interacting with the environment helps learners identify incongruities between hypothetical scenarios of the world they study in and the real world.
- *Self-regulation and intrinsic motivation*
  Students should assume responsibility for their own learning and success. They should be encouraged towards self-regulation - planning and setting goals, assessing progress, determining their own strategies, and making adjustments in response to errors. To foster this, tasks and activities should be engaging and relevant, but of sufficient depth and complexity to simulate the real world. The overall approach should motivate learners intrinsically, helping them to be absorbed and attentive, and instilling an urge to explore the resources further.
- *Collaborative learning*
  Collaborative learning is a common practice within constructivism. Proponents advocate that knowledge construction should occur through social negotiation, rather than via inter-learner competition for recognition. The viability of individual understanding can be evaluated by social

negotiation (Savery & Duffy, 1995) as learners share and debate perceptions and interpretations. Dodge (1996) considers collaboration with other learners to be preferable to individual learning.

- *Personal learning objectives*

  Learners within constructivist systems participate in negotiating their own learning goals; thus different learners have different objectives.

- *Flexible entry behaviours*

  In contrast to the objectivist's bottom-up specification of entry behaviours, constructivists have a top-down, just-in-time approach that fills gaps in prior learning as needs arise. Responding to criticism of the lack of prescribed entry behaviours, Perkins (1991b) acknowledges that mechanisms should be used to provide learners with adequate support in managing complexity.

- *Integrated assessment*

  For assessment to be valid, it should be embedded in the context of learning, rather than based on testing in a decontextualised academic setting. In constructivist learning, the focus of assessment is on what learners themselves construct in real-world contexts, based on authentic learning tasks (Jonassen, 1991b). Learning and tasks may differ from one learner to another. Cunningham (1991a) states that skills cannot be considered independent of the problems to which they apply. A subskill is not effectively learned unless it is used correctly in solving problems. In this light, assessment must be in terms of authentic task performance.

  Dick (1991) concludes that assessment is the greatest challenge of constructivism, suggesting that constructivist assessment measures learning gain rather than investigating whether learners master specific skills. A further issue, due to the collaborative nature of constructivist learning, arises when group work is assessed and individual efforts are hard to determine. Assessment of individuals can only be done during actual task execution, which further increases the responsibilities of the educator. Constructivist assessment is a major issue, which is discussed further in 2.4.2.2.

- *Constructivist view of errors*

  Errors are viewed as largely transitional and even beneficial where supporting educational structures are available (Hannafin, 1992). Mistaken ideas help learners to establish tentative, dynamic beliefs and hypotheses, which are challenged when they encounter new, contradictory information. In this way errors facilitate the evolution of learners' beliefs - they can be modified and extended as new information becomes available and experience is attained. Experiential, progressively-refined knowledge is retained better than correct information taught objectively.

2.4.2.2 Constructivist evaluation

Constructivist evaluation and assessment of learning are complex and demanding processes, entailing multiple aspects and multiple evaluators. According to Reeves (1997) constructivist epistemology espouses that 'reality' is individually and socially constructed on experience, and learning can be estimated only through observation and dialogue.

If constructivism is a valid approach for the presentation of instruction and promotion of learning, it should also provide valid criteria for evaluating that learning. The issue is complex and so integral to the essence of constructivism that it is explicitly considered in this section, firstly giving criteria and proposals of Jonassen (1991a; 1992) and secondly the opinion of Cunningham (1991a; 1992).

1. Jonassen's evaluation principles

Jonassen (1991a; 1992) proposes constructivist evaluation criteria:

Goals of learning and goals of evaluation

- *Goal-free evaluation methodologies*
  Evaluation should not be biased by specific project goals, but be based on needs assessment.
- *Socially-constructed / negotiated meaning*
  Goals of learning can be negotiated with learners. The negotiation process, in the form of argumentation, can be used as evidence of learning. Subsequently, the objectives can be used as a negotiating tool for guiding learners through learning and for self-evaluation.
- *Purpose of evaluation*
  Evaluation implies an appraisal or value judgment about performance, relative to stated criteria. If learning is the process of knowledge construction, then that itself should be the most appropriate goal and the constructor him/herself is also an apposite evaluator. In this sense, evaluation is less a reinforcement tool and more a tool for self-analysis and metacognition.

Context of instruction and context of evaluation

- *Context-driven evaluation*
  Constructivism assumes that instruction is anchored in meaningful, real-world contexts. Concomitantly, evaluation should occur in rich and complex contexts. The learning environment should also serve as the evaluation environment and, itself, suggest relevant assessment opportunities. Within this context, learners should acquire advanced knowledge in order to solve complex, domain-dependent problems, and this knowledge should be assessed.

- *Authentic tasks*

  Tasks should have real-world relevance, and activities should be integrated across the curriculum. Learners should be able to select appropriate levels of difficulty or involvement, since not all can become masters in every content area.
- *Multiple perspectives*

  It is important to present multiple perspectives in learning situations and equally important to reflect multiple approaches in evaluation. Thus a single set of evaluation criteria or a single type of outcome is unacceptable. Various possible outcomes should be identified that each provide acceptable evidence of learning. A further implication is that a single evaluator is unable to provide a complete and objective appraisal, and that ideally, there should be a panel of reviewers.
- *Multimodality*

  A portfolio of products should be evaluated. Different products should represent various perspectives, modes, or dimensions of learning in the domain.

Evaluation of more than just domain knowledge

- *Knowledge construction*

  Outcomes of constructivist environments should assess higher-order thinking such as the *find* level of Merrill's taxonomy (2.3.3.3), the *cognitive strategy* level of Gagné's categories of learning outcomes (2.2.3.1), and the *synthesis* level of Bloom's taxonomy (2.3.2.2).
- *Experiential construction (process versus product)*

  Learners' mental processes should be evaluated rather than their behaviour or products of that behaviour, i.e. the processes of knowledge acquisition and learning gain should be evaluated. This kind of assessment should be integrated into instruction, so that both educators and learners are aware of the progress. Such self-monitoring also enhances learners' metacognitive awareness.

2. Cunningham's evaluation suggestions

Further insights on assessment of constructivist learning come from Cunningham (1991a; 1992) who argues that successful completion of a task demonstrates the success of learning, and no separate test is required. Two issues are:

(i) Who is to judge whether a task is successfully completed?

(ii) If a task is done by a group, how is one to know how much each member has learned?

The answer to the first question is that the teacher/facilitator should judge whether a task has been successfully completed by gathering a variety of information - observation, talks with learners and other teachers, learners' journals, individual and group tasks, and even scores in standardized tests. All except the last are an integral part of the educative process and emerge naturally from the task, i.e. this kind of assessment is not a separate activity done after instruction.

True constructivists reject the computer analogy of the mind (see 2.3.3.1 and 2.3.3.2), believing that the mind does not *process* information - it *constructs* it, based on experience and ongoing interactions. The constructions are assessed by seeing whether students can construct plausible solutions to the tasks assigned them, as well as by checking their self-awareness of the constructive process. The context-specific nature of interpretations should be investigated, as well as the value of multiple perspectives. This approach stresses the role of the teacher/facilitator, instead of placing the onus on an instructional developer to produce both the instruction and the assessment mechanisms.

With regard to the second issue, namely, collaborative tasks, the purpose is not to promote the attainment of the same objective by each group member. The objective is a joint goal - to solve the problem on hand, and the contributions and attainments of each group member are expected to vary widely (Cunningham, 1991a; 1992).

2.4.3 Views and controversies about constructivist learning

This section examines how constructivism goes beyond cognitive learning models and overviews the reaction to constructivism from various theorists - sometimes referred to as the paradigm war.

Cognitivism and constructivism

In general, cognitive psychologists propose that the role of mental processes is to represent the real world, doing so by an appropriate sequence of mental activities - activities which are externally manipulated by a teacher or by instruction. Even Piaget, considered to hold constructivistic epistemological philosophies, viewed mental constructions as representations of the real world. Contemporary cognitive theorists, however, question whether the mind should merely transfer knowledge from the external world into human memory or whether it should produce its own, unique conceptions of events and objects, based upon individual perceptions of reality (Jonassen, 1991b).

As explained in Section 2.4.1, constructivism assumes that learners construct the meaning of objects/events by interpreting perceptions in terms of their own experiences, interactions, beliefs, and biases. There is a strong link to collaborative learning (discussed in Section 2.5.1), in that constructivists refer to shared/negotiated meanings as those achieved by learners together with a teacher or other learners. The social constructivist strategy (Gruender, 1996) is to define knowledge as the result of consensus, thus deriving it from social structures.

Perceptions and controversies regarding constructivism

This subsection reports on certain reservations about constructivism during the past decade, considering their current validity and discussing some of the issues, an investigation which continues through this chapter and Chapter Three.

In the late 1980s and early 1990s constructivism took the educational world by storm. Initial publications propounded the philosophy and the ethos, but offered little in terms of alternative models of instructional design, an omission which fueled the reactive criticism from proponents of the traditional models, and unleashed a vigorous debate. This **dearth of constructivist strategies for use in practice was, in fact, due to the intrinsic nature of constructivism itself**. Constructivists faced the paradox - how could their stance, which decried objective reality and externally correct meanings, prescribe systematic procedures for instruction? It would be much more appropriate to suggest guidelines and principles than to specify prescriptions and systematic procedures. **And so it took time for metaconstructivist models** (Section 3.4.3) **to appear**. However, by the mid 1990s, flexible but pragmatic constructivist models were in use and in print, as well as guidelines for open learning environments and problem-based learning in harmony with true constructivism. Constructivism is more concerned with **true learning** than it is with instruction based on detailed, **meticulously-prepared instructional material**.

A balanced view, presented by Dick (1991), points out that constructivist learning opportunities are costly to develop, require technology to implement, and are difficult to evaluate. Ten years on, in retrospect, the first two limitations are no longer valid - the technologies of the Internet and World Wide Web are tailor-made for constructivist learning.

He also raises the salient issue of the epistemology of constructivism - is it true instruction? Dick defines instruction as an educational intervention driven by specific outcomes. Objectives, materials, and procedures are targeted towards these goals and assessment is geared to determine whether the desired changes in behaviour (i.e. learning) occur. By this definition, **constructivist interventions do not qualify as instruction**: 'It may be a desirable educational intervention, but it does not appear to be instruction' (Dick 1991:44), an opinion is reinforced by Reeves (1997:60): 'Direct instruction is replaced with tasks to be accomplished or problems to be solved that have personal relevance for learners'.

In vigorous dialogue, Merrill (1991) and Molenda (1991) (protagonists of traditional and cognitive instructional theories) object to criticisms and characterizations of conventional instructional systems technology by constructivists such as Cunningham (1991a; 1991b) and Duffy& Jonassen (1991a). They also disagree with the label, *objectivism*, for the foundations of traditional instructional design.

In general, Merrill holds a pragmatic position, arguing that the assumptions of both constructivism and his own contemporary cognitive methodology, ID_2 (Merrill, Li & Jones, 1990a; 1990b; 1990c), might be equally valid or invalid, and that empirical verification would be required to determine this. Although some assumptions and prescriptions of moderate constructivism are consistent with traditional instructional design theories, extreme constructivism (Section 2.4.4) represents an approach at odds with the ethos of classic instructional theory. Merrill (1991) and Molenda (1991) object to the constructivist beliefs that:

- *Learning and meaning are unique to each individual, and there are many meanings for any event or concept*: Merrill and Molenda query the results if students were to construct personal interpretations in cases such as learning to read, basic arithmetic operations, or historical facts. In a medical context, Merrill dreads the prospect of a surgeon negotiating new meaning regarding the anatomy of the heart, a reference used as a classic indictment of radical constructivism;
- *Authentic tasks are the sole valid context of learning*;
- *Simplification should be avoided*: In contrast to constructivism, which decries decontext-ualization, Merrill advocates the isolation of generalities by removing them from context (i.e. analyzing a task into components). However, in line with constructivism, he supports learning from experience in authentic contexts;
- *All testing should be integrated*: Merrill perceives the value of integrated testing as a supplementary mechanism, provided that not all testing is integrated;
- *Specific learning objectives are not always possible*;
- *Content should not be prespecified*: They disagree with the claim that meaningful knowledge construction cannot occur where relevant information is predefined; and
- *Merrill's work is labelled as objectivist*: Merrill does not believe that knowledge is merely transferred to the student's memory; he is on record as stating that students organize knowledge in mental models as a result of experience (Merrill, Li & Jones, 1990a; 1990b; 1990c).

With hindsight ...

Major changes have occurred in the realms of learning and instruction. It is understandable that constructivism, as proposed by theorists a decade ago, shocked classical instructional designers!

In the current learning-centric culture, conversely, those who promote traditional instruction are the ones considered out of line. It is not considered correct to speak of *prescriptive instruction* - the idea is to *facilitate learning* and in a democratic educational community, the learner is considered as powerful as the facilitator. Constructivism is strictly non-prescriptive, a philosophy contrary to the norms of instructional theories and systematic procedures designed to instill information and skills into learners. Dick (1991) recognized that constructivism was reacting to limitations in the then instructional-design theory and practice. He accepted constructivist proposals regarding learning contexts and multiple exposures as vital for the transfer from academia to the real world, and foresaw that seminal developments would result from this alternative paradigm.

A moderate constructivist approach has much to recommend it in areas such as the teaching of problem-solving skills. Extreme constructivism appears contrary to general educational principles, although it may be appropriate for certain types of learning.

Learners' frustrations and remedies

Constructivists themselves (Perkins, 1991b), realize that constructivism, although learner-centred, may be intimidating and frustrating to learners, due to its propensity for complex, authentic tasks and the lack of specification of appropriate entry behaviours. He suggests that the problems could be mitigated by a sensitive awareness of how learners perceive constructivist learning.

Perkins proposes a way of handling *cognitive complexity*. In conventional instruction, learners are presented with, and tested on, simplified models in educational settings - an approach which Perkins calls *conflict buried*. Learners are frequently unable to extend these simplified models to accommodate the target models of the real world. Constructivist learning, by contrast, is anomaly-driven - *conflict faced* - challenging learners by avoiding the inconsistencies of over-simplification. This tends to induce cognitive conflict. A third way - a middle route - could be termed *conflict deferred*, whereby learners are invited to learn a new way of thinking and talking about phenomena until the concept has consolidated, at which point a naive, simplified educational model is introduced and the relationship explored.

Perkins states that the role of task management which learners are expected to play in complex constructivist settings is not always adequately scaffolded. Thirdly, Perkins suggests that learners struggle with the idea of finding out matters themselves, when they are aware that the facilitator could tell them all they need! Such learner-resistance can hinder a committed learning experience.

2.4.4 Radical/extreme constructivism

This section presents some quotations relating to extreme constructivism and comments on them. Radical constructivism (Jonassen 1991b) does not accept the existence of any real world or objective reality. Some of the most extreme viewpoints are:

> *Theoretical views are personal creations, embedded in a social context, within a social community that accepts the assumptions underlying the perspective. There is no right or wrong here in any absolute sense* (Cunningham, 1991b:26).

> *There are many meanings or perspectives for any event or concept. Thus, there is not a correct meaning that we are striving for* (Duffy & Jonassen, 1991a:8);
>
> *Each has their ... own understanding, rather than both encompassing some common reality* (Duffy & Jonassen 1991a:9).

These viewpoints deny that learning and perception can be referenced to a defined objective reality, positing that individuals mentally represents a personal reality, i.e. interpretation plays a major role in the personal, constructed reality. Reigeluth (1991) promotes constructivism as a valuable perspective to facilitate learning, yet considers these views as extreme ideology. Acknowledging a certain truth and situations where various views are equally plausible, Reigeluth insists that situations do occur where a correct meaning exists. Cases arise where learners need to acquire objectivist understandings from an expert, and where there is some shared reality - without it, there would not even be language.

In contrast to Cunningham, Reigeluth believes that higher-level skills can be taught outside of the problems to which they apply. He agrees that they can be well taught within the context of a problem, especially those cognitive strategies that are specific to one context. But others are generalizable and transferable, and can best be learned in decontextualized settings. Much of what extreme constructivists advocate is more related to curriculum theory than to instructional theory, and is more relevant to decisions regarding what should be taught, than how to teach (Reigeluth, 1991).

2.4.5 Constructivist learning theory: related perspectives

This section reports on stances and theories in harmony with constructivist viewpoints, and also introduces the highly constructivist realms of open learning environments and problem-based learning. There is brief mention of the concepts of interpretivism, positivism, and chaos theory.

2.4.5.1 Situated cognition and anchored instruction

Situated cognition (Winn, 1990; Jonassen, 1991b) proposes that learning occurs most effectively when *contextualized* in realistic settings, and that real-world learning environments should be created rather than isolating instruction in artificial educational contexts. Learners' problem-solving methods depend on the situation in which they encounter them. Situated cognition goes beyond cognitive science - it presents complex and illogical situations, whereas cognitive learning assumes that problems are well-structured and can be solved by reasoning. The idea of *situating learning* in rich, real-world contexts is a strategy (Braden, 1996), rather than a theory/ philosophy of learning. Where a context is not the actual real world, it can be simulated or made authentic by providing realistic tools and activities. A similar approach is *anchored instruction*, rooted in constructivism. It aims to engage learners actively by locating/anchoring instruction in realistic problem-solving environments.

2.4.5.2 Cognitive apprenticeship and cognitive flexibility theory

Cognitive apprenticeship proposes that instructional processes take an analogy from the way a craftsman guides an apprentice. Instead of adhering to predetermined scripts, teachers and instructors should coach and guide, and focus on solving real-world problems, analyzing the learner's strategies and responding accordingly (Jonassen, 1991b). Braden (1996) views situations that foster cognitive apprenticeship as implementations of situated learning. A related philosophy, *cognitive flexibility theory* (Spiro, Feltovitch and Coulson, 1994), introduced in 2.3.4.4, is a conceptual cognitive-constructivist model emphasizing case-based reasoning. It builds on other constructivist theories, such as those of Bruner and Piaget. Cognitive flexibility avoids oversimplification, and stresses conceptual interrelationships, presenting multiple representations and themes on the content.
It is important to note that these approaches are

- cognitive,
- based on constructivistic assumptions, yet
- with an objectivist grounding (Jonassen 1991b).

They are therefore hybrids - using sound characteristics from each of the approaches, and demonstrating that it is not possible to demarcate and classify learning philosophies and approaches into strictly-defined categories. Neither are they new ideas - good instructors and sound instructional design have traditionally used real-world examples to amplify instruction.

2.4.5.3 Constructivist learning environments & open-ended learning environments

According to Piaget (Inhelder & Piaget, 1958), learning is a personal, idiosyncratic experience, characterized by individuals developing knowledge and understanding via forming and refining concepts. Learners should take control, making decisions in line with their needs and cognitive states. A paradox occurs when effective learning environments, particularly technology-based environments, constrain learners' decision-making freedom (Squires, 1999). When this occurs, users sometimes *subvert* the designs to meet their own needs, using them in ways not originally intended. Designers and instructors can acknowledge subversive use and deliberately design for it by supporting freedom and flexibility. This is termed *incorporated subversion* (Squires, 1999) and recognizes the active role of learners in configuring learning environments to their own needs. Good design should be volatile, adaptable to the context. Constructivist learning environments and open-ended learning environments, introduced in this subsection, meet this criterion. They are elaborated in Chapter Three, which describes their practical characteristics in 3.4.4.2 and 3.4.4.3.

1. Constructivist learning environments

Explaining the purpose of *constructivist learning environments* (CLEs), Jonassen (1999) contrasts the objectivist view with constructivist conceptions. The objectivist view aims to transfer knowledge from teachers or transmit it via technology, so that it can be acquired by learners. Constructivist conceptions, on the other hand, assume that knowledge is individually constructed or socially negotiated. The purpose of CLEs is to engage learners in constructing knowledge based on their interpretations of experience, and to make meaning from a model which comprises a *problem, question, or project* as the focus of the environment, surrounded by various interpretive and intellectual support systems. The learner's goal is to solve a problem or complete a project. Jonassen points out that objectivism and constructivism both engender learning, but from different, complementary perspectives. In fact, some of the best environments use combinations of both methods, applying them in different contexts.

Cognitive and contextual authenticity

From the guidelines for constructivist software and interactive learning environments, Squires (1999) concludes that the distinguishing characteristics of CLEs correspond with the notion of authenticity, which he considers from cognitive and contextual perspectives:

- *Cognitive authenticity* - learners should:
  - Explore and simulate the behaviour of systems and environments, and receive feedback indicating the effect of their actions on the system;
  - Express personal ideas and opinions, with the environment providing mechanisms to articulate these ideas;
  - Experiment and investigate various solutions to problems, using multiple perspectives, multiple knowledge representations, varied cases and contexts;
  - Own and take responsibility for their learning experience; and
  - Be presented with complex environments in keeping with the ill-structured nature of the real world, but with scaffolding available to support learners in coping with this complexity.
- *Contextual authenticity* - learning varies according to its context and the components of the learning environment, in particular whether it is a teacher-centred or learner-centred environment. Contextualized learning implies:
  - Knowledge should be situated in personal experience;
  - Knowledge should be distributed, so that technology augments learning rather than supplanting it; and
  - The role of the teacher changes to management and facilitation of learning.

These twin concepts of cognitive and contextual authenticity imply that learners should work in environments that support idiosynchratic exploration and expression, resulting in learning experiences which are unconstrained by the designer. Self-expression and exploration are synergistic features well suited to an environment designed for *incorporated subversion* (Squires, 1999). These characteristics are applicable both to technology-based learning and to learning environments that use computerized tools to support and augment learning, but are not managed by a particular technological system.

2. Open-ended learning environments

Open-ended learning environments (OELEs), also called *open learning environments* (OLEs), are closely related to CLEs. In contrast to direct instruction with clearly-defined external objectives and organized concepts, open environments are learner-centred environments that support learners as they manipulate and interpret processes associated with relevant problems and content domains. Individuals play a role in uniquely defining meaning. Cognition and context are linked as learners engage in learning activities, making decisions, modifying, testing, and refining their (possibly flawed) initial beliefs. An OELE incorporates a variety of approaches, resources, and tools that facilitate cognitively complex tasks that demand critical thinking, self-direction, problem solving, and integration of knowledge (Hannafin, Land & Oliver, 1999). The intended benefits of open-ended, exploratory, authentic learning can best be realized by technology-based implementations.

OLEs are particularly useful in situations that promote divergent thinking and where multiple perspectives are more appropriate than a single correct perspective, for example, ill-structured problems and cases that require exploration, manipulation and discovery, and personal interpretation. They are unsuitable for convergent learning tasks where all learners should acquire the same knowledge, skills and interpretation.

2.4.5.4 Project-based learning and problem-based learning (PBL)

1. Project-based learning

Land and Greene (2000) emphasize the need for learners to become sophisticated consumers of information - knowing how to locate resources, extract and organize relevant information, and synthesize items from various sources into a cohesive whole. Traditional, externally-centred instructional methods fail to address the needs of the information society and its cognitive requirements. Similar to OELEs, *project-based learning* entails learner-directed investigation as they develop solutions to open-ended situations. The projects are real-world cases, inviting genuine research on the part of learners, thus contributing towards the construction of meaningful solutions.

Learners' responsibilities

The main requirements of learners are the:

- Generation of a question or problem to drive learning needs, and
- Development of a product/s to address the question or problem identified.

The fact that the driving questions are learner-generated results in a need-to-know attitude, which makes the information acquired personally meaningful and leads to purposeful integration. Throughout the process, learners seek and locate relevant resources, and must organize and integrate the information found. In a study by Land and Greene (2000) to investigate the processes used by learners in project-based learning, the critical factors identified for achieving coherence were metacognition, domain knowledge, and system knowledge.

Teachers' responsibilities

Traditional teaching focuses around content and structured curricula. A topic is subdivided, then taught according to prescribed *procedures*; this is the usual format from pre-school to adult education. In project-based / problem-based / case-based approaches, however, educators choose *problems* that cover the necessary aspects of content and skills. They must be structured (Norman & Spohrer, 1996), so that in the course of a solution, learners naturally interact with and study all the relevant topics. This means implicit, rather than explicit, instruction - education within activity.

2. Problem-based learning

The general model of problem-based learning (PBL) was developed in medical education in the 1950s (Savery & Duffy, 1995). It has become widely accepted and can be used in the first two years of medical science degrees to replace the traditional lecture-based approach in subjects such as anatomy, physiology, etc. A medical PBL session usually proceeds as follows: Students are divided into groups; each group has a facilitator, and is presented with a problem in the form of a patient presenting symptoms. The students discuss the problem and generate hypotheses, each taking a chance to reflect on his/her current suppositions, as they jointly determine the learning issues involved. Then they tackle self-directed learning, since there are no assigned texts. They separate to collect information and resources from libraries and databases, and may hold verbal consultations with available lecturers. The group meets again to re-examine the problem in the light of the resources acquired, and finally make their diagnosis, providing the rationale for their beliefs.

Similar approaches are used in other instructional contexts and domains. Problem-based learning contributes to the intrinsic motivation of learners. People learn best when engrossed in a topic, actively exploring and searching for new knowledge, and acquiring new skills to solve the problem at hand. Assessment includes peer-evaluation and self-evaluation, and there may or may not be tests.

Application

PBL has a constructivist framework, but can occur inside and outside of constructivist learning environments. CLEs provide infrastructure and resources, in contrast to situations where students, individually or collaboratively, are presented with a problem to tackle on their own. The former is possibly more suitable for scholars, and the latter appropriate for adult learners and tertiary-level students, who have more convenient access to facilities and resources.

2.4.5.5 Interpretivism

Constructivism is closely related to interpretivism. Interpretivists (Willis, 1995) are anti-foundationalists, who believe there is no single correct route or particular method to knowledge. They accept that whatever standards are used are subjective.

2.4.5.6 Positivism

Positivism (Gruender, 1996; Cohen, Manion & Morrison, 2000) is a doctrine holding that all genuine knowledge is based on sense experience and can be advanced only by observation and experiment. It is associated with the 19th century French philosopher Comte, and is a movement that attempted to design large philosophic systems for the purpose of constructing human knowledge of the external world using man's immediate perceptual experiences as well as the tools of the new logic. The renowned philosopher, Bertrand Russell was a further proponent of these systems. It turned out to be extremely difficult to establish knowledge of objects and events external to themselves, using only data derived from their internal states, and manipulating it deductively. Positivism's base of resources turned out to be inadequate to account for deductive human knowledge. The term *positivism* has been used in several different ways by various philosophers and social scientists, and it cannot easily be assigned a single consistent meaning. Hwang's (1996) view of positivist thinking associates it with a broad variety of theories and practices, such as *Comtean-type* positivism, logical positivism (non-realism), behaviourism, empiricism, and cognitive science.

2.4.5.7 Chaos theory

Chaos theory (Jonassen, 1990) postulates that all systems, even simple deterministic ones, are subject to unexpected fluctuations and give rise to complex, unaccountable behaviour. Even predictive systems are subject to random fluctuations. In the context of learning, there is no guarantee that instructional intervention will result in the desired learning; it can only increase its probability. Gleick (1987, cited in Lebow, 1993) suggests that learners' emotions, attitudes, values and goals are involved in learning situations, affecting them in unpredictable ways. Moreover, methods that work well under certain conditions do not function effectively under others. The influence of chaos theory on complexity theory, as applied to learning and the design of instruction, was mentioned in 2.3.4.1.

Chaos theory accepts the presence of uncertainty, and is the antithesis of reductionist science which examines systems in terms of their parts. It rejects deterministic predictability, which is a goal in most applied sciences. Chaos theory challenges entropy theorists by claiming that even under conditions of maximum entropy, interesting structures may evolve - chaos may, in fact, lead to order. While simple systems may give rise to complex behaviour, complex systems frequently produce simple, structured behaviour (Jonassen, 1990).

Chaos theory has its origins in the field of mathematics and physics (You, 1993). Quantum physics rejects the presumption that the universe is a predetermined system, instead viewing physical phenomena as indeterministic and unpredictable. This viewpoint - along with disorder, complexity, instability, diversity, and disequilibrium - represents chaos. However, within the unpredictability of these disorderly phenomena, there are structures of order - *order within chaos* - and this is the core of chaos theory. Disorderly phenomena cannot be described by a mechanistic Newtonian worldview - in fact, it was dissatisfaction with Newtonian determinism that gave rise to chaos theory.

> *The irony of chaos theory is that while educational systems appear quite chaotic, students do learn, often in spite of our most systematic interventions*
> (Jonassen, Campbell & Davidson, 1994:35).

2.4.6 Discussion of constructivist learning

Section 2.4 has reported on theoretical and conceptual aspects of the field of constructivist learning. Practical applications, in the form of constructivist design principles/guidelines and descriptions of constructivist learning environments are given in Chapter Three, Section 3.4.

With the initial advent of constructivism, many practitioners did not perceive it as a powerful contending theory, but as an instructional strategy appropriate for certain learning situations. That was an under-estimation - the constructivist perspective, with its paradigm shift, has had a major impact on educational approaches and practices.

Where is constructivism in the domain of learning theories?

Reigeluth (1997) associates constructivism with cognitivism in respect of their learning goals, pointing out that cognitive and constructivist theories pursue higher-level goals than behaviourist theories. Other theorists and practitioners also position constructivism with the cognitive sciences, as mentioned in the introduction to Section 2.4. On the other hand, Jonassen (1991b) and Hwang (1996) perceive cognitivism as residing alongside behaviourism under the umbrella of objectivism (see 2.2.4.1 and 2.3.4.5) and view constructivism as a philosophy of its own at the extreme of a continuum. This viewpoint is addressed further in Section 2.8, where it is illustrated by Figure 2.4.

Table 2.4 Assumptions of objectivism and constructivism (Adapted from Jonassen 1991b:9)		
Aspect	**Objectivism**	**Constructivism**
View of reality	External; Structure is determined by entities, properties, and relations; Structure can be modeled.	Determined by learner; Structure is a product of mental activity and symbolic procedures; Structure relies on interpretations.
View of the mind	Processor of symbols; Mirror of universal reality; Abstract machine for manipulating symbols.	Builder of symbols; Interpreter of nature; Conceptual system for constructing reality.

Table 2.4 lists some assumptions of objectivist and constructivist theories, summarizing the epistemological significance of Jonassen's continuum. Objectivism and constructivism are considered as alternative, mutually exclusive perspectives on learning and understanding (Duffy & Jonassen, 1991b). The constructivist approach contrasts with objectivist paradigms, in that objectivism is about the *objects* to be known (relating to products), whereas constructivism addresses the ways in which learners *construct* knowledge (relating to processes). A further difference is that objectivism holds learning to be tractable, whereas constructivism perceives it as infinite and generally not subject to analysis.

An alternative model was proposed by Cronjé (2000) to integrate the traditionally conflicting objectivist and constructivist approaches to instructional design. Cronjé proposes they are not mutually exclusive and portrays the two as complementary approaches, since, in practice, many learning events incorporate aspects based on objectivist traditions as well as elements of constructivism. This approach is also elaborated in Section 2.8, where it is depicted in Figure 2.5.

In which learning areas should constructivism be applied?

Constructivism is appropriate for learning in ill-structured domains where there is scope for personal interpretation. In the teaching of well-defined concepts (for example, mathematics, spelling, molecular structures, etc.) the objective reality is absolute reality, and learners' knowledge should conform to the defined meaning.

Schisms exist between the philosophical assumptions and perspectives of behaviorism, cognitivism, and constructivism, resulting in major differences between the ways they are practically applied in authentic settings of instruction and training. The contentious nature of the debate impacts upon educational practice and instructional systems development, which are described in Chapter Three. There is a strong case for a conciliatory position, for examination of the various philosophical positions and paradigms, in order to identify their mutual roles and to reconcile conflicting views.

2.5 Cross-paradigm characteristics

Certain characteristics and features transcend paradigms - they are aspects that must be considered in most kinds of instruction, regardless of the underlying philosophy. Some such issues are collaborative work within a learning event, the locus of control, and the matter of creativity in instruction so as to motivate learners and meet affective needs. These are introduced in Sections 2.5.1, 2.5.2, and 2.5.3 respectively, and are discussed further in Sections 3.5.1, 3.5.2, and 3.5.3, which suggest practical ways of achieving them.

2.5.1 Collaborative learning and co-operative learning

Co-operative learning and collaborative learning have become standard practices in the 1990s. Collaborative learning can be implemented in various ways, but usually refers to groups of learners working jointly on a project, with the intention of producing a joint product. This can be done either by face-to-face contact in classroom situations or in distance-learning situations, in which case the collaboration is usually online, i.e. computer-mediated communication (CMC).

2.5.1.1 The difference between collaborative and co-operative learning

Panitz (1996) explains the distinction between collaborative and co-operative learning.

Collaborative learning is a philosophy of learning, more than just a classroom technique. It is an ethos that respects each group member's individual abilities and contributions. Authority and responsibility are shared within a team, and the underlying premise is consensus building. Collaborative learning ties into the social constructivist movement, and practitioners tend to apply this approach in the classroom, at meetings, in the community, and in their homes. The emphasis is on active participation/ interaction on the part of both learners and instructors.

Co-operative learning is defined as a set of processes whereby people work together to accomplish a specific goal or to develop a content-specific product. It is more directive than a collaborative system and is usually controlled by an instructor/teacher, i.e. it is teacher-centric, whereas collaborative learning is learner-centric. Collaborative learning empowers students in doing tasks that are frequently open-ended, whereas in co-operative learning, the instructor retains ownership of the task, which involves a closed problem with a correct answer or predictable solution.

In general, collaborative learning can be seen as broader than, and as a superclass of co-operative learning. Co-operative learning is the better means to achieve mastery of foundational knowledge, but once students have reached/attained competency in a field, they are ready for collaborative work.

Both collaborative and co-operative learning are effective learner-learner-educator paradigms, particularly in the context of interactive environments where students take more responsibility for their own learning as well as a sense of responsibility toward their peers (Panitz, 1996). For each educational goal or community of learners where group work is required, the more appropriate of the two methods should be chosen.

2.5.1.2 Key elements of co-operative learning

Johnson & Johnson (1991) define key components of co-operative learning. The intended ethos is general collaboration and the term 'co-operative' learning does not imply limited applicability. Based on these, key elements of both collaborative and co-operative learning are:

- *Shared goals* - learners perceive that they can achieve their goals only if others do so too, leading to discussion, mutual assistance, and encouragement to work hard;
- *Positive interdependence* - this is the context of interaction; each learner is aware of his/her key role in the group and learns to help others and share knowledge with them;
- *Individual accountability* - personal responsibility of each learner to achieve the group's goals;
- *Promotive interaction* – the ability to communicate and debate ideas within a group;
- *Interpersonal skills*;
- *Empowerment of learners*; and
- *Co-operative evaluation systems* - which vary, depending on whether groups are homogeneous or heterogeneous. If scores are allocated and also used to grade learners individually, homogenous groups may be required. Learners thus compete on two levels - equal competition within the group, but also between groups. In other competitive situations, learners are assigned to heterogeneous groups so that each group is a cross-section of the class and has an equal opportunity of high performance. Ranking of groups permits more than one winner.

Collaborative learning frequently occurs within the context of constructivism, where it serves as a means of broadening perspectives and facilitating resolution of cognitive conflict (see 2.4.2.1) as learners jointly seek to clarify and justify their viewpoints (Duffy & Jonassen, 1991a). Constructivist learning can be enriched by collaboration within heterogeneous groups, where inherent diversity exposes learners to multiple perspectives. Collaboration enables learning from one another as members jointly search for resources, support one another's reasoning processes, and develop the required products. Furthermore, groups provide an actual audience to pay attention to each individual's viewpoint, thus enhancing confidence and motivation. Learning to collaborate effectively in an educational setting imparts valuable life-skills that prepare learners for the workplace. Metacognitive skills, in particular, are learned more effectively within groups (Bandura, 1977, cited in Singhanayok & Hooper, 1998).

2.5.2 Learner-centricity and learner-control

A *learner-centred paradigm* view learners holistically, considering both their cognitive and affective interpretations of learning situations. Learner-centredness transcends theory and paradigm boundaries - it is found in various learning systems and environments across the spectrum of learning and instructional perspectives. In a learner-centric situation the role of an instructor or teacher migrates from directing and controlling instruction to facilitating and managing learning. Learner-centricity also relates to motivating learners and meeting their particular needs.

Norman and Spohrer (1996) suggest that learner-centred education can be best accomplished when problem-based teaching approaches are used, since this tends to match the problems and aspects addressed to the learners' interests and needs. They propose a strong relationship between learner-centredness and learner-engagement, stating that an engaged student is a motivated student. (Motivation is addressed directly in Section 2.5.3.)

The role of computer technology

Media and technologies also play a role in learner-centricity. Continuing on the theme of learner-centredness and motivation, Norman and Spohrer (1996) emphasize the power of computer-based instruction and multi-media technology to engage learners with their rapid interactivity and powerful provision of information. Kozma and Clark have set up a discussion on alternative instructional media, comparing whether instruction is more or less effective when delivered by a different medium (Clark, 1994; Kozma, 1994). Jonassen, Campbell, and Davidson (1994) refer to this debate, suggesting that this type of discussion distracts from the main purpose of media by over-focusing on the objectivist and instructionist conceptions of media. A shift is proposed in the debate and the practice of instruction from a media-centred to a learner-centred approach, emphasizing the role of media in **supporting individual learners**, rather than investigating how media controls them. Instructional methods should use media to support human cognitive processes, to engage learners, to optimize strengths, and to minimize weaknesses.

In the behaviourist and cognitive paradigms, *learner-control and customization* refer to systems where control may be provided over lesson segments, their sequence, and termination points. In cognitive situations tending towards constructivism, learners can take the initiative by controlling their progress through material, and may select their own learning activities. Such systems may also provide access to optional enriching resources such as help, glossaries and permit learner-management of the quantity and of work, or complexity-level of examples and questions. Dick (1991) points out that in true constructivism, designers offer learners discretion to select the content they study, the resources they use, as well as their approach to the topic.

Reigeluth (1997) highlights *customization* as the most important key marker that distinguishes instruction and learning in the Information Age from that of the Industrial Age. In society, mass production, mass marketing, and mass communication are being replaced by customized production and marketing (facilitated by the Internet) and personalized communication (using cellular phones). Interactive television is soon to be reality. All these paradigm shifts result from the Information Revolution and its associated technologies. Education and training must keep pace and instructional theories should accommodate the concept of learning experiences geared to the requirements of individual learners.

2.5.3 Creativity and motivation

Creativity in instruction is strongly related to the affective and motivational aspects of learning, aspects which are overviewed separately in this section.

2.5.3.1 Creative instruction

Creativity and creative instruction are complex concepts - subjective, unsystematic, hard to define and hard to measure. They entail originality, novelty and innovation, but without loss of functionality. In an instructional context, creativity is generally equated to engaging learners and is considered synonymous with producing instruction that motivates learners. An alternative approach to the epistemology of creativity is Rowland's (1995) view that the term 'creativity', when applied to a design product, focuses on elegance and uniqueness, i.e. on its conciseness or on ways in which it brings beneficial change to a problematic situation. This study holds the former approach, viewing creativity as a motivating and engaging force.

A joint creator of the most widely-used ID model (Dick & Carey, 1996), responds to critics who claim that following a prescribed linear development process results in boring instruction. Dick (1995) argues that 'boring instruction' originates from a limited approach that adheres rigidly to a design model - completing each step before considering the next, instead of using the model pragmatically. Dick advocates flexibility and creativity within the traditional ID paradigm. Defining creative instruction as instruction that 'engages learners and goes beyond their expectations', he proposes conditions for producing creative instruction:

- *Client criteria* - relevance of clients' needs and perceptions; learner analysis to match their interests; analysis of learning context and performance;
- *A supportive environment for instructional designers* - including recognition and reinforcement by management of creative instruction;

- *Participatory design* - whereby instructors and learners are included, not only in formative evaluation, but also in design. Learners should be explicitly asked whether the instruction held their attention and interested them. The criteria traditionally used to evaluate systematically designed instruction have been effectiveness and efficiency - these should be explicitly supplemented with the criterion of creativeness;
- *Flexibility in applying the instructional strategy component of an ID model* - how to chunk and present information and what kinds of activities to use - adhering to Keller's ARCS model (see 2.5.3.2) to address the issue of motivation; and
- *Technology* - designers should exploit the current technological and multimedia opportunities to provide creative, engaging, and motivating instruction. (This was Dick's proposal in 1995 - how much more apt it is in the 21st century!) Chien Sing (1999), in the context of creative instruction, proposes technology as a medium for creating engaging and meaningful interaction that supports learning and makes it fun.

In training environments within business and industry, instructional designers are re-evaluating the notion of creativity. Recognizing that many of the instructional materials and methods are repetitive and uninteresting, Caropreso and Couch (1996) stress the value of creativity and innovation in the workplace. Certain established business practices are creative, for example, brainstorming and analogical thinking, which are based on intuition and instinct. This same ethos should be applied to instructional design, so as to develop motivational products that train personnel effectively and richly, and foster positive attitudes within employees. The factors that result in creative instruction must be considered. Although there are naturally creative individuals, many of the necessary skills can be learned (Caropreso & Couch, 1996). When systematic design models are used to produce instruction, they should be used heuristically - modifying the approach for the task at hand.

The role of computer technology

Designers express their ideas via a medium (Kozma 2000). Within the field of educational technology, media must be considered as more than mere delivery devices. A sound understanding of media and its relationship to design and learning can inspire creativity and enable powerful designs.

Flow theory (Csikszentmihalyi, 1990) relates to *optimal experience* - situations where participants concentrate intently and experience deep concentration, interaction, and enjoyment from an activity. Enjoyment goes beyond pleasure, in that pleasure can be passive in nature, while enjoyment requires direct participation, as often occurs during physical activities but can also be evident in contrived environments. There is a deep, effortless involvement, going beyond awareness of everyday matters and frustrations. *Flow* (Rieber, 1996, cited in Steyn, 2001) is described as a state of happiness and satisfaction, attained when adults are so absorbed in an activity that they seem to 'flow' along with it. Jones (1998) argues that a state of flow can be provided in computer-based learning environments (CBLEs), maintaining that technologists and educators building CBLEs should take cognisance of the way players become totally engrossed in (non-educational) computer games. Understanding the factors that result in 'flow' can contribute to greater creativity and understanding of engagement in computer-based learning and electronic learning. Learners experiencing flow would achieve a deep level of engagement and temporarily almost lose touch with external concerns.

Creativity that engenders creativity.
A most important, aspect of creativity is the use of instructional/learning methods that engender creativity within learners themselves. Not only should learning and instructional materials be creative, but they should also foster individual and environmental creativity among their target group.

2.5.3.2 Motivation

Creativity and the power of educational processes and products to hold attention are strongly related to motivation in the learner. Motivation refers to the attitudinal and affective aspects of instruction and learning. There are two kinds of motivation - extrinsic and intrinsic (Wager, 1998). *Extrinsic motivation* is associated with reinforcement external to the work/behaviour of learners, for example, gold stars in a child's workbook, prizes for top achievers, marks deducted for non-adherence to deadlines. External reinforcement implies subtle control of behaviour by some other party, through positive or negative consequences. *Intrinsic motivation* and demotivation relate to internal states or effects, such as senses of anticipation, challenge, satisfaction, dissatisfaction, frustration, etc.

In general, this study holds the **ethos of intrinsic motivation**. On occasions however, extrinsic motivation can effectively complement intrinsic motivation, such as when individuals or groups are awarded prizes or explicit acknowledgement for their efforts. Some individuals are intrinsically motivated by high achievement - and with the tendency towards an egalitarian society, such learners (achievers) must not be overlooked; they should be offered opportunities for self-actualization.

Motivational design (Keller, 1983) entails instructional strategies that motivate learners and do not frustrate them. For example, the ARCS model of motivation (Keller & Suzuki, 1988) advocates gaining <u>a</u>ttention, demonstrating <u>r</u>elevance, instilling <u>c</u>onfidence, and providing <u>s</u>atisfaction. Dick (1995) suggests that routine use of the ARCS strategy would ensure that designers develop instructional experiences that engage learners. Moreover, in the current paradigm (or threat) of life-long learning, motivational characteristics in adult learning materials can contribute towards positive attitudes in those undergoing training and re-training.

The role of computer technology

Norman and Spohrer (1996) assert the motivational value of interactive multi-media technology. Engaged students are motivated students, and computer-based materials have the potential to hold attention by providing information that is concrete, yet perceptually easy to process. The rapidity of interaction and feedback also engage learners. In the current trend towards problem-based learning, a well-chosen theme can serve as primary motivator, obviating the need for extrinsic motivation.

However, the prime purpose of instruction is to promote learning. Creativity in instructional methods must remain **supplementary to learning**. Where materials and resources result in engagement and fun, these aspects must enhance the product, not dominate it or reduce its status to 'edutainment'.

Affective-cognitive connection

There has been increasing awareness of the importance of motivating learners, as researchers realize the connection between the cognitive and affective domains (Martin & Wager, 1998). This viewpoint is upheld by complexity theory introduced in 2.3.4.1 (Tennyson & Nielsen, 1998).

Price (1998) traces the traditional dichotomy between cognition and emotions - cognition being long regarded as logical and rational, and emotions being considered passionate and inarticulate. In the behaviourist era of emphasizing observable behaviour, topics such as emotions, mental states, and intentions received little attention from educational researchers. Cognitivists explored mental processes, but from the perspective of cognition rather than affect. But recent research is inquiring how emotions and intelligence interrelate, demonstrating connections and reciprocal interactions between affect and cognition (Greenspan, 1997, cited in Price, 1998), and noting that every sensation gives rise to an affect or emotion, termed *dual-coding*. Greenspan's principle of dual-coding holds significant implications for instruction and learning. Human information processing models of cognitive science (see 2.3.3.1 and 2.3.3.2) suggest that learners encode information cognitively in mental schemata, but do not address *emotion schemes* (Greenberg, Rice, & Elliott, 1993, cited in Price, 1998). Emotion schemes are said to integrate cognition with motivation (goals, needs, and intentions), affect (sensory and physical feelings), and action (responses and tendencies). Designers of instruction should consider how learners might process information emotionally as well as cognitively, accepting that human experience is dual-coded, in that it is recognized for its personal and emotional significance, as well as its information content (Price, 1998).

The challenge to instructional theorists, designers, and educators in general is to synergistically integrate creative, motivational, and unconventional approaches to create instructional materials and events that effectively promote authentic learning. Ideally, instruction should be enjoyable, as well as effective and efficient.

2.6 The learning-focused paradigm of instructional theory

Due to changed philosophies and dramatic advances in information technology, major changes have occurred in the domains of instructional and learning theories, and particularly in the associated disciplines of the design of instruction and the generation of learning environments. It is termed the *new paradigm of instructional theory* (Reigeluth, 1996c), and Reigeluth's description of its emergence and attributes is outlined in this section. As a background to the notation and terminology, it would be worthwhile to consult the *Terminology* section at the beginning of this thesis.

2.6.1 Towards a new paradigm of instructional theory

This chapter has described evolution and developments in the realms of instructional and learning theories. Reigeluth's classic *Instructional-design theories and models*, *Volume I,* (Reigeluth, 1983) explains the discipline of instructional design and sets out various theories and approaches which dominated the field in the early 1980s. Major changes such as those described in this chapter, led Reigeluth to start a second volume in the mid-1990s to set out some of the new methods of instruction, to highlight current issues and trends, and to show the interrelationships between diverse theories. Reigeluth terms this information age theory *the new paradigm of instructional theory*, alternatively *learning-focused theory* (Reigeluth, 1996a), and lists key markers, shown in Table 2.1, that distinguish it from the industrial age paradigm.

Table 2.5
How Information Age and Industrial Age instructional theory differ
(Reigeluth 1996c:2; 1999:17)

Industrial Age	Information Age
Standardization	Customization
Centralized control	Autonomy with accountability
Adversarial relationships	Co-operative relationships
Autocratic decision making	Shared decision making
Compliance	Initiative
Conformity	Diversity
One-way communication	Networking
Compartmentalization	Holism
Parts-oriented	Process-oriented
Teacher as king	Learner as king

Of the ten concepts listed under the Information Age paradigm, all except networking have been mentioned either in Section 2.3 or Section 2.4 on cognitivism and constructivism respectively. The major changes indicated have been partly due to advances in knowledge about human cognition and learning theory, partly due to changed philosophies, and are also a response to advances in information technologies offering new instructional capabilities.

2.6.2 Relationship between instructional theory and instructional methods/strategies

The integral relationship between instructional theory and instructional methods/strategies precludes discussion of one without the other. Traditional instructional theory was implemented by *basic methods*, and according to Reigeluth (1996c) it has been scientifically proven that these consistently increase the probability of certain types learning under given conditions. Such methods include, for example: the use of generalities, demonstrations, examples, and practice with feedback for teaching skills. Then there are the *variable methods*, which are alternative means of delivery, such as print, computer, video, or audio, used to implement the basic methods. Reigeluth (1996c:2) suggests that the use of basic methods, implemented by variable strategies, occurs cross-paradigm:

> *Behaviourists recognized this, and called them examples, rules, and practice with feedback. Cognitivists also recognized this, but naturally had to give them different names, such as cognitive apprenticeship and scaffolding. And, yes, constructivists also recognized this, and even radical constructivists "walk the walk" even thought they may not "talk the talk". An analysis of instruction designed by some very radical constructivists reveals a plentiful use of these very instructional strategies.*

Associated with the *new paradigm of instructional theory* described in this section, is a *new paradigm of instructional systems development* (Reigeluth, 1996a; 1996b*)*. This is described in Section 3.6 of Chapter Three and focuses on actual design, development, and practical characteristics of instruction in the context of learning-focused theory.

2.6.3 Learning-focused instructional theory

Reigeluth's proposed new paradigm of learning-focused instructional theory (Reigeluth 1996c; Reigeluth & Squire, 1998) goes beyond the basic methods. Such theories should provide guidelines for the design of learning environments that offer learners appropriate combinations of challenge and guidance, empowerment and support, self-direction and structure. Flexible guidelines for *instructional situations* should indicate how and when learners should:

- Take more initiative and responsibility for leaning;
- Work in teams as well as individually on authentic, real-world tasks;
- Be able to choose from different sound methods to support learning;
- Use advanced technology as an integral part of the learning process;
- Be allowed to persevere until they reach appropriate standards;
- Participate in peer-teaching, using well-designed resources; and
- Operate in situations where the teacher acts as a guide and facilitator.

Learning-focused theory should address the issue of using, and choosing between, the wide variety of current variable methods, such as project-based learning, problem-based learning, simulations, tutorials, and team-learning.

2.6.4 Involvement of user-designers

The *user-designer* concept of systems design theory refers to cases where learners have decision-making roles regarding the instructional methods they use (Reigeluth, 1996c). For example, design teams, comprising all stakeholders including learners, could create computer-based learning tools that would support learners in creating or modifying their own instruction. This could mean a mixed initiative approach, whereby learners choose their own instructional strategies at certain times, while the computer would, at other times, select strategies based on learner-input. The instructional designer's role would move from extensive direct instructional decision-making towards determining the mechanisms of decision-making. This is in line with cognitive theory, in that learners' progress and attitudes are continually tracked and monitored, so that decisions about appropriate instructional strategies are taken for individuals or teams, during instruction, rather than for an entire body of learners, preceding instruction. Learners should be able to decide, under varying degrees of guidance and instructor-modification, both about what to learn (content) and how to learn it (strategy).

A variation on the user-designer concept occurs where the instructional framework is pre-designed, but instead of the instructional designer prescribing, he/she acts as facilitator and the users - teachers/trainers, along with learners - play leading roles in the design team. This approach recognizes the need to empower those who actually create and deliver the instruction. Particularly where users are teachers, their knowledge of educational theory and practice should be recognized, in the trend towards convergence of the roles of teacher and instructional designer. In practice, teachers take ownership of the instruction they deliver - often creating and using their own materials and instructional activities, or else they deconstruct and adapt pre-constructed materials for their own purposes. Vincini (2001) reflects on *participatory design* methods and their worth in achieving learner-centred design to add value to traditional instructional design.

Note: the separation of the roles of instructional designers and teacher does not usually occur in formal education in the researcher's home territory of South Africa. Though educators use standard resources and prescribed texts, they frequently design their own instruction - i.e. they serve as instructor-designers. The separation of roles does, however, occur in vocational and other training situations.

2.6.5 How the new paradigm of instructional theory differs

Instructional-design theories and Models: Volume II, edited by Reigeluth, was published in 1999 (Reigeluth, 1999). In contrast to *Volume I*, characterized by commonality and complementarity among theories of instruction, *Volume II* communicates diversity. The diversity relates to varying values and to different kinds of learning promoted by the different theories.

1. Values (underlying philosophies) have traditionally been overlooked in instructional-design theory, yet they play major roles in two important aspects of instruction. First, they influence the learning goals that are selected and - as is apparent from this chapter - goals of the various theoretical platforms differ considerably, indicating a broad spectrum of underlying values. Second, they impact on the means chosen to implement a given goal, namely, the different instructional methods and approaches. For any given goal, there is always more than one way of attaining it. Traditionally, instructional design process models have relied heavily on research and empirical data about which methods work best, but the concept of 'working best' depends, in turn, on the qualitative values and associated criteria that are used to judge the methods.
2. Different kinds of learning which have formerly received insufficient attention should be addressed, such as: character education; learner-attitudes and values; emotional, motivational and affective aspects; problem-solving skills; cognitive strategies, comprehension and higher-order thinking skills; as well as motor skills.

In an introductory chapter Reigeluth (1999), using excerpts from and adaptations of other publications (Reigeluth, 1996a; 1996c), addresses some of the pertinent issues such as defining instructional-design theory, and explaining how it differs from learning theory and from practical instructional systems development (ISD) processes. These descriptions are included in the *Terminology* discussion at the beginning of this thesis, and are highly relevant to the present study. Aspects from certain theories discussed in *Volume II* are incorporated in Chapter Three.

2.7 A theoretical subdivision according to educational psychologists

Before concluding this chapter on instructional theories and perspectives, it is fitting to summarize a somewhat similar study. The structure in Chapter Two is the synthesis of the present author, from the viewpoint of an instructional practitioner. An analysis from the viewpoint of educational psychology provides enrichment and insight on the evolution of instructional and learning theories. It approaches cognition and learning from the latter perspective, using its terminology to describe phenomena similar to and related to the traditional and emergent instructional theories addressed in this study.

Greeno, Collins, and Resnick (1996) conclude that current educational research is undergoing a major advance that will deepen the theoretical understanding of the fundamental processes of cognition, learning, and teaching, so as to contribute to the practice of education. The emerging psychology of cognition and learning includes individual, social, and environmental factors in a coherent theoretical and practical understanding. In the process of this advance, there is merging and extension of concepts and methods that, previously, developed relatively separately. The fields involved in this cross-disciplinary merger are cognitive science, ecological psychology, ethnographic anthropology, and sociology. The most promising aspect of this science is the relationship between the theoretical and the practical. The ultimate goal is the provision of articulate and valid principles that can be laid down to enhance educational practice.

The authors categorize the traditions in educational theory and practice into three general perspectives within psychological research, namely, the *behaviourist/empiricist* view, the *cognitive/rationalist* view, and the *situative/pragmatist-sociohistoric* approach. For each view the corresponding means of (i) knowing, (ii) learning and transfer, and (iii) motivation and engagement are overviewed.

The content of their work holds value as a parallel setting out of relevant and related information, and is briefly outlined in this section, as a self-contained essay, without discussion or interpretation on the part of the present researcher.

2.7.1 The behaviourist/empiricist view

Under this view (Greeno, Collins & Resnick, 1996), *knowing* is based on an organized collection of connections among elementary mental or behavioural units. One way in which it is educationally implemented is via stimulus-response associations.

Greeno, Collins, and Resnick (1996: 21) define learning as 'the process by which knowledge is increased or modified'. Under the behaviourist/empiricist view, means of effective *learning* are shaping, in which the learner becomes oriented to the general conditions under which learning will occur, and instrumental conditioning, whereby desired responses are reinforced. The classical conditioning of this approach identifies required behaviours and responses. As a side-effect, important unintended learning also occurs, called incidental learning.

Transfer of learning, i.e. applying it in new situations, is a vital issue in educational psychology. Transfer, under the behaviourist/empiricist view, is the strengthening and adjustment of the associations between stimuli and responses. This can be done by personalizing instruction - supplying feedback contingent on the individual learner's response - as is done by programmed instruction and computer-based learning systems. These acquired associations impact upon new situations, depending on how many and which kinds of associations were acquired in previous situations. A response learned as an association to one stimulus generalizes to other stimuli that are similar.

In the view that learning involves forming stimulus-response associations, *engagement* is assumed to occur mainly due to extrinsic *motivations* - rewards, punishments, and positive or negative incentives. Although these motivations are external to the individual, their consequences depend on the internal goals of the individual. Engagement in an activity depends on the individual's subjective opinion regarding the outcomes of the activity. Behaviourists use the terms positive and negative reinforcement to emphasize their view that that rewards tend to strengthen particular response tendencies, and punishments weaken them. When a learner is motivated to respond correctly, informational feedback provides positive reinforcement for accurate responses and *vice versa*, along with information to guide an adjustment in performance. Such feedback also corresponds with the so-called connectionist view, in which information fed into the system strengthens certain connections and weakens others.

2.7.2 The cognitive/rationalist view

This approach (Greeno, Collins & Resnick, 1996) treats *knowing* as having structures of information and cognitive processes that recognize and construct patterns of symbols to understand concepts. Abilities such as reasoning, problem-solving, and analysis also occur in this way. Learning is believed to occur via general schemata for understanding and reasoning as set out in Piaget's (1988) formulations of children's cognitive development. Furthermore, learning must be viewed as conceptual understanding - transforming the learner's significant initial understanding, rather than simple acquisition of knowledge on a blank slate. Conceptual understanding changes as it develops. Newell and Simon's (1972) cognitive theory of problem solving via the human information processing model is a further implementation of the cognitive/rationalist view. Another important theme in the cognitive view of knowing is the concept of metacognition - the capacity to reflect on one's own thinking, to manage and to monitor it.

Learning is considered to occur via intellectual activity, and understanding is gained by an active process of construction rather than by passive assimilation of information or rote memorization. This cognitive/rationalist view incorporates a constructivist programme with studies of cognitive development in specific subject matter domains.

In the cognitive perspective, *transfer* is assumed to depend on acquiring an abstract mental representation in the form of a schema or structure that is invariant across various situations. This general schema has to be acquired in initial learning, along with practice in applying it to examples. If learners understand that the solution of a problem is actually a general method and if they grasp the general features of the learning situations to which the method is applicable, then they are more likely to be able to generalize and apply it elsewhere. Research has indicated, however, that transfer to new situations often does not occur.

When learning is viewed as the acquisition of knowledge and the understanding of information, concepts, principles, and strategies, then *motivation and engagement* are viewed as intrinsic interest in a domain of cognitive activity. This cognitive view treats engagement in learning as an intrinsic property of the relation between individuals and the organization of information. Cognitive researchers guard against rewarding learners extrinsically for things they would choose to do for intrinsic reasons - they might then no longer be prepared to do them for intrinsic reasons alone. Malone's framework (1981) for intrinsic motivation proposes challenge, fantasy, and curiosity to make learning environments more engaging.

2.7.3 The situative/pragmatist-sociohistoric view

This perspective (Greeno, Collins & Resnick, 1996) addresses the way that *knowing* is distributed in the world among individuals (with relation to the tools and resources they use) and communities (with regard to their practices and co-operative activities). This situative view of knowing represents a fundamentally different way of analyzing instructional tasks. Rather than investigating the component subtasks that comprise the act of knowing, there are analyses of the characteristics of successful activity. Knowing can be implemented by participation in the practices of communities. Communities are groups of individuals, and the abilities of groups are considered to be knowing, i.e. collective knowing is considered, as well as individual knowing. This kind of knowing within the context of social practice, has traditionally been studied more by anthropologists and sociologists. The relevance to current teaching is the importance of learners being able to participate in social practices, both in and out of formal educational settings.

When knowing is viewed as the practices of communities and the abilities of individuals to participate in those practices, then *learning* is the interactive strengthening of those social practices. Such learning includes forms of initiation in which beginners are originally peripheral to the community activities, observing and practicing. Later as they become more adept and their abilities strengthen, they progress to more central participation. Similar learning occurs during apprenticeship in work environments where apprentices are coached and supervised by masters.

In the view of learning as participating in a community of practice, *transfer* is a problem, since many of these resources and supports do not carry over to different communities or situations.

The view of learning as becoming more adept in participating in community practices, focuses on *engagement* that maintains interpersonal relations within the community or a satisfying interaction with an environment. An example of powerful social learning is young children learning to speak their home language by communicating with the family.

In conclusion

This essay by Greeno, Collins and Resnick (1996) demarcated educational principles and practices under three general perspectives of a behaviourist/empiricist view, a cognitive/rationalist view, and the situative/pragmatist-sociohistoric approach. The first two correspond closely to the behavioural and cognitive perspectives discussed in this chapter, and add further value in their explication of views of knowing, learning and transfer, and the motivation of learners.

2.8 The three paradigms - isolationist or integrative?

This section presents various opinions on the roles of the paradigms, and the relationship between philosophies and practical strategies. It serves as a backdrop to Section 2.9, where the researcher personally overviews the issues and concludes the chapter.

Constructivism and associated problem-solving in authentic contextualized environments are bringing major change to traditional classroom instruction and, in certain quarters, are perceived as a threat. The 'paradigm war' (Willis, 1998) is a major topic in social science and education, involving several of the authors cited in this chapter. It remains to be seen whether the alternative philosophies that instituted the dialogue will transform the discipline of instructional design, both in the way it is taught and the way it is practiced.

Certain designers differ with the Dick and Carey model on a philosophical level, perceiving it as obsolete, positivist, objectivist thinking. They argue that there should be a paradigm shift towards constructivist frameworks. Chien Sing (1999) suggests that change should be perceived as a catalyst that can contribute to dynamic and authentic learning environments. Constructivist classrooms have the potential to stimulate multi-perspective, self-directed learning and to provide scaffolds for interactive, meaningful knowledge construction.

Can aspects of the paradigms be combined?

- Gruender (1996) identifies the exclusivity of their focus as a serious weakness within both objectivism and constructivism. Certain proponents of each are obsessed with limited scope and restricted practices. The exclusivity remains undefended and would not stand up to scrutiny.
- Jonassen (1991a) describes three stages of knowledge acquisition: introductory, advanced, and expert. *Introductory learning* comprises the initial stages of knowledge assembly, basic skills, and integration in a domain when learners have little prior knowledge about a content area or skill. Jonassen suggests that objectivist approaches are the best to support this stage, which often involves basic practice and feedback. A transition to constructivist approaches is advised for the second stage, *advanced knowledge* acquisition, where learners solve complex domain-dependent problems. Constructivist environments can effectively represent complexity and ill-structured aspects, where apprenticeship and coaching are appropriate instructional strategies. Thus Jonassen argues for a hybrid approach, combining objectivist and constructivist learning, so as to optimize on each. At the *expert* level of knowledge the learner is usually a professional, no longer under formal instruction.
- Jonassen (1999) also acknowledges that situations exist where objectivism and constructivism are compatible - complementary design tools, offering differing perspectives on the learning process.

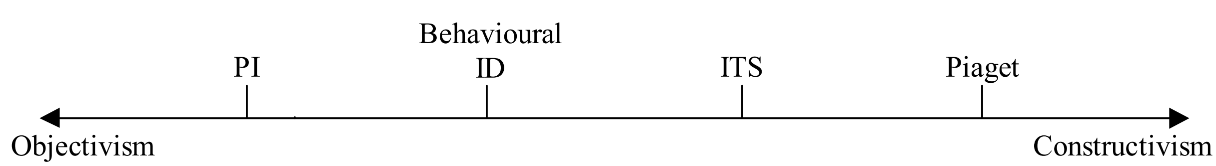
- According to Reigeluth (1989), all descriptive theories have some useful contribution to make. In proposing a new learning-focused paradigm, Reigeluth (1996c; 1999) suggests flexible guidelines for instructional situations, in the face of many disparate theories and models. Despite the new paradigm, it is important not to discard strengths of the former paradigm. Learning-focused approaches should incorporate much of the knowledge generated by previous instructional-design theories and models, but restructured into different configurations in the context of the new.
- Braden (1996), a proponent of the systematic development of instruction, claims that there will always be domains where systematic ID and structured instruction are the most appropriate methods.
- Willis (1998) points out that constructivist learning covers a broad scope - within it there remains a place for direct instruction and the learning of basic information There are different types of learning and students do not have to discover everything for themselves. Sometimes direct instruction is appropriate; sometimes less structured learning environments that still provide much support and direction; and sometimes very open learning environments, using rich resources for undirected learning experiences. Constructivists are concerned about boring, out-of-context instruction, as well as the type of instruction that produces inert knowledge, which is hard to apply or transfer. Some opponents of constructivism reduce the differences between traditional and constructivist instruction to the issue of whether the practitioner is aiming to develop instruction that is efficient and effective, or setting out to entertain and engage students. Willis views this as an over-simplification, denying that constructivism aims to provide fun at the expense of effective learning.

What is the relationship between objectivism and constructivism?

The descriptions in this chapter of objectivism (externally mediated reality) and constructivism (internally mediated reality) tend to the extreme positions. Figure 2.4 depicts Jonassen's (1991a) portrayal of some of the stances and implementations situated on a continuum between extreme objectivist and constructivist poles.

Figure 2.4 The objectivist-constructivist continuum

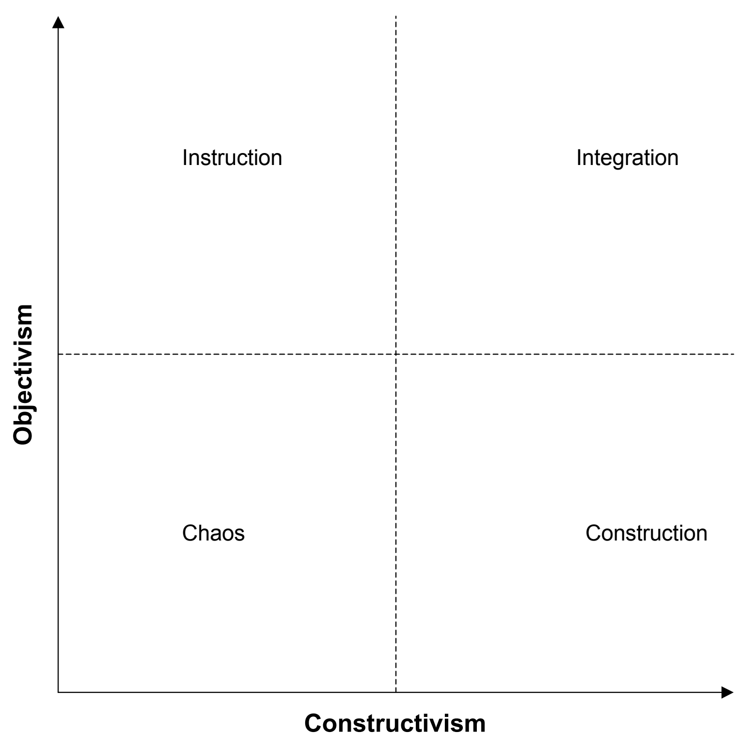
(Jonassen, 1991a:28)



An alternative approach (Cronjé, 2000) is to position objectivism and constructivism on independent axes at right angles (90º) on the Cartesian plane, instead of placing them at extremes (180º apart) on the same axis. The significance of this model is a proposed integration of the two traditionally conflicting stances to present them as complementary approaches. Cronjé analysed various learning programs and found pragmatic incorporation of both objectivist and constructivist elements in their learning events. This model forms an appropriate representation of the findings. When objectivism and constructivism are juxtaposed on a right angular system of axes, as indicated in Figure 2.5, four quadrants result, dependent on the degree of objectivist and/or constructivist learning appropriate for a particular content domain. Each of the four: instruction, integration, construction, and chaos, has its own valid place in the field of teaching and learning.

Figure 2.5 The objectivist-constructivist plane

(Cronjé, 2000:4)



The *chaos* quadrant, low on both objectivism and constructivism, represents serendipitous and incidental learning. *Instruction* is high on objectivism and low on constructivism, and is the domain of programmed learning, tutorials, lectures and drill-and-practice. The *construction* quadrant corresponds closely to the conventional views of constructivism, constructionism, and cognitivism. When objectivism/instruction and constructivism/construction are combined, the fourth quadrant of *integration* arises. This is the domain that typically emerges when an instructional designer conducts goal analysis to determine required learning outcomes, and then applies both objectivist/instructionist and constructivist/cognitivist learning events to achieve the desired outcomes (Cronjé, 2000).

Is the debate about strategies or about principles?

A danger of the debate (Willis, 1998) is its tendency to revolve more around instructional strategies than on the higher, conceptual, theory-based level. Only in the context of the theoretical and epistemological frameworks used by the proponents of the different viewpoints, can the designer understand the practical issues on which there is disagreement. To position the debate at that level misses the point and raises three problems (Willis, 1998):

1. What is actually a strategy? When is a strategy a strategy and when is it a social environment or characteristic of the learning experience?
2. Traditional design models inherently promote the use of certain instructional strategies and neglect others. The current trend to customization of instruction requires the option of alternative methods, and there are some approaches that are compatible with direct instruction, but that complicate or hinder the design of instruction. Some of the alternatives are, for example, case-based learning, anchored instruction, and microworlds.
3. Constructivist theory, while it does emphasize some strategies, such as anchored instruction and collaborative learning, is more **focused on principles than on strategies**. Constructivists are primarily concerned about changing the thinking on teaching and learning, rather than intent on promoting or eliminating particular strategies.

2.9 Conclusion

Conventional instruction, from pre-school through to adult education, is traditionally based on a system where topics are subdivided taught according to prescribed procedures. An evolution, almost a revolution, within this system is currently impacting dramatically upon all aspects of teaching and learning.

This chapter focuses on the theory - on the progression in learning theories and instructional theories. The relationship between theory and practice is vital - it is essential that practical applications be founded on sound, learning-focused, theoretical frameworks. The next chapter addresses this, moving on to survey practical applications, namely instructional practice and models for the development of instructional systems and learning environments. Chapter Four then examines salient features across the spectrum of paradigms, and proposes an integration of selected learning theories and characteristics into a synergistic framework.

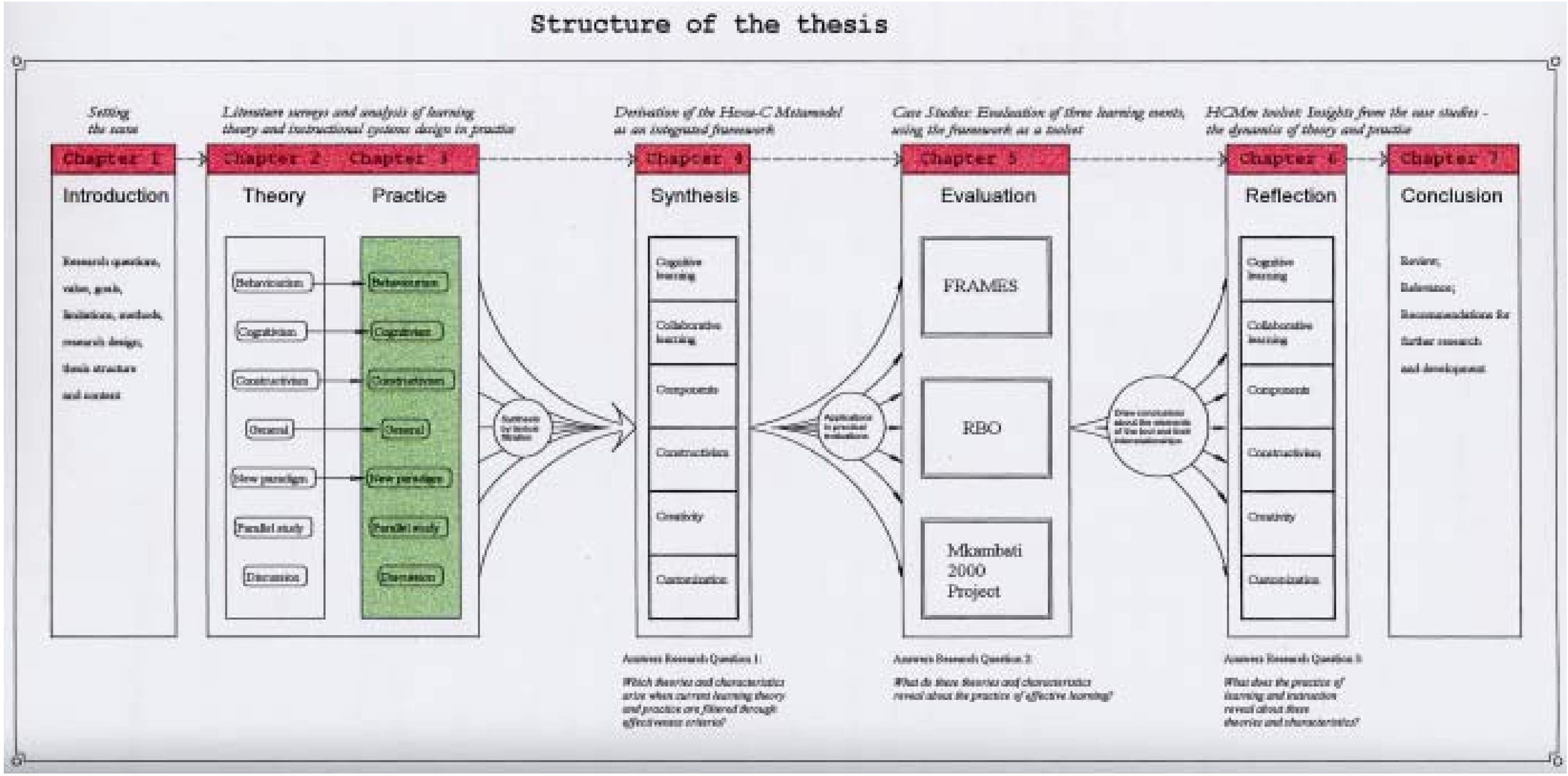
A delimitation of this study is that the theories to be selected for incorporation in its metamodel should be from the cognitive family (Sections 1.2, 1.3, and 1.6.2 in Chapter One). This study is based on the stance that the promotion of cognitive learning is an advance on rote learning, shaping, and behavioural change. Current educational focus, anticipating the 21st century, is going yet further. There is emphasis on the context within which learning occurs, addressing both the presentation of content and the approaches to be used by individual learners as they encounter and construct knowledge and acquire skills. There is a clear shift from a fixed autocratic approach to flexibility and learner-centricity within a context of guidance and support. There is awareness of the utility of technology, yet avoiding control by technology.

The new learning theories and models posit that the most effective learning occurs in authentic contexts, promoting the utility of open-ended and problem-based learning within thematic, inter-disciplinary learning environments. Furthermore, instructional and learning theories are being broadened to encompass the affective domain. As well as learner-achievement, learner-attitude is receiving increasing attention. Context should incorporate more than just the authenticity of learning situations - it should also take cognisance of learners' values and where appropriate, aim to guide values and norms.

The main purpose of this chapter was to trace the development of instructional and learning theories, focusing discussion at a conceptual, theoretical level. Objectivist and constructivist positions were explained. Instructional and learning strategies were overviewed, as were cross-paradigm issues, such as characteristics and features of learning events and environments. It appears that the underlying philosophy of instruction or a learning event, however, defines the major thrust of instruction and impacts upon the strategies used and features implemented.

> *We do not have one large bowl of instructional strategies from which to make our selections each time we design instructional materials. We have many bowls, and they contain families of instructional strategies that are based on different theories of learning and instruction. There is a behavioural family of instructional strategies, a cognitive science family, and at least two constructivist families. The selection of an instructional strategy should be made from within a theoretical framework that guides decision making* (Willis 1998:8).

This does not mean, as Willis points out and as Hannafin *et al* (1997) propose, that all the strategies selected will originate from the same theoretical base. They should, however, be chosen within a theoretical context. In determining the strategies, features and characteristics of instructional materials and learning events, the instructional designer or instructor-designer should also carefully consider the type and purpose of learning. The prime issues, therefore, are the nature of the learning event itself and an appropriate theoretical foundation.


Structure of the thesis
Chapter 1
Introduction
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Theory
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RBO
Mkambati 2000 Project
Chapter 6
Reflection
Chapter 7
Conclusion

Chapter Three

Practice

Learning and instructional systems design in practice

Good instructional design practice is informed by theory, but not slave to it (Wilson, 1999:5).

3.1 Introduction and discussion of terminology

If instructional theory provides the philosophical and paradigmatic foundations for fostering learning, how do designers and practitioners of instruction turn theory into practice? What impact does a specific theory have on the way learning events are developed and instruction is implemented? In 1900, Dewey (cited in Reigeluth, 1983; 1997) called for a linking science - a *design science* - between learning theory and educational practice. Instructional design comprises that linking science (Reigeluth, 1983; Bednar *et al*, 1992). Methods of applying learning and instructional theories are incorporated into the discipline of instructional design (ID), which relates to structured processes for the generation of instructional products and strategies.

This chapter surveys the application of theory to practice. The design, development, and nature of instructional systems are investigated, in line with the definition of instructional systems design in Section 1.6.1, and the various stances and directions are related to the instructional and learning theories introduced in Chapter Two. The changes within, and the evolution of ID are investigated and discussed as it progressed from a behaviourist base - implemented by systematic ID models, through the advent of cognitivism, to constructivism - implemented mainly within learning environments. This is done in Sections 3.2, 3.3, and 3.4 (which respectively describe applications of the theories introduced in Sections 2.2, 2.3, and 2.4). Each section commences with a discussion, then continues with examples and descriptions of various models, thus constituting a broad and comprehensive overview of instructional practice and instructional design models.

Some of the issues and changing trends faced by designers and educators were succinctly described even before the advent of the nineties (Reigeluth, 1989:68):

- *Instruction versus construction*
- *prescription versus description*
- *analysis versus synthesis*
- *validity versus optimality*.

Instructional design is concerned with developing and improving instruction by applying optimal methods to promote knowledge acquisition and skills in the learner. In certain domains, the purpose of instruction is to enable learners to acquire bodies of knowledge and skill that have been developed over generations by scholars and scientists. Various methodologies exist for systemization of instructional models, procedures and materials, i.e. support for the development of instructional strategies. A variety of theories and models exist, some being explicit prescriptions defining stages and procedures for designing instruction, and selecting appropriate strategies to achieve the required instructional outcomes and conditions. Some are tightly coupled to a specific learning theory or perspective - demonstrating a strong relationship between a theory of learning and a method of instruction, while others, also closely coupled to a learning theory - advocate an instructional approach, but without presenting explicit methods or techniques. Yet others are instructional designs developed inductively by trial and error without any assumptions regarding learning processes.

3.1.1 Instruction and learning: theory to practice

Just as executive practice within a state is based on the underlying political ideologies and agendas, in the same way, **most instructional prescriptions, practices, and strategies have a theoretical basis and are closely related to underlying instructional and learning values, philosophies, and psychological perspectives**. There are opposing viewpoints as to the desirable nature of instruction and, consequently, as to the procedures and techniques for developing learning and instructional material and environments. Instructional designs are therefore not just descriptions of instructional sequences, but are an implicit expression of the designer's personal theory of learning (Duffy & Jonassen, 1991a). The philosophy of the individual or organization that implements the instruction also plays a role and, in practice, instructional plans and strategies, as set out by the instructional designer, are frequently modified by teachers, instructors, and trainers to accommodate their own ethos.

The literature review in Chapter Two surveys the major paradigms of instructional and learning theory, commencing with the behaviourist approach. Most of the traditional models of instructional systems development (ISD) and instructional practices are moulded by objectivist-behaviourist traditions (Winn, 1990; Duffy & Jonassen, 1991a). Subsequently, theories of human information processing and cognitive science perspectives were incorporated to produce learning materials that simplified human reception and conprehension, still using direct instruction teaching strategies. Constructivism - which initially emerged as theoretical verbal and published repartee - has crystallized into an instructional paradigm with proposed models and learning resources. The constructivist thrust is away from direct instruction towards participative learning where knowledge is encountered in the context of real-world problems. This entails a departure from systematic design procedures, since constructivism aims to support, rather than instill, learning. Furthermore, it approaches a domain from multiple perspectives, which is incongruous with explicitly defined learning strategies.

Theory-technology relationship

Not only is there a close relationship between contemporary theories of instruction and learning and the associated methods of instructional systems development, but there is also a strong relationship between the theoretical paradigms and the technologies used to implement them. The philosophies described in the previous chapter are not all new, and none of them is inextricably coupled to a single technology. However, the current technological and multi-media implementations are new and versatile. The computer and Internet provide powerful enabling technologies for ideas dating back throughout the twentieth century (Norman & Spohrer, 1996). In particular, they facilitate innovative implementation of the constructivist paradigm.

3.1.2 Terminology

The reader is referred to the *Terminology* section at the beginning of this thesis, should it be necessary to review general terms and concepts of the discipline of instructional design. However, certain important concepts are explicitly incorporated in this section, namely: explanations of descriptive and prescriptive theories, a brief sketch of interrelationships between these theories and the concepts of ID as the progression occurs from theory to practice, and a description of grounded design.

Descriptive and prescriptive theories

(Simon, 1981; Reigeluth, 1983; 1989; 1997; Braden, 1996; Merrill *et al*, 1996)

Simon (1981) distinguishes between the *natural sciences* and the *design sciences*. Natural sciences relate to natural phenomena - for example, the sciences of physics, astronomy, anatomy, biology, etc. Their associated *descriptive theories* describe how phenomena occur, setting out the laws and relationships governing these systems.

Design sciences, or the *sciences of the artificial* (Simon, 1981), relate to phenomena not governed by natural laws and procedures; they are man-made applied sciences such as medicine, engineering, architecture, and instruction, for which the associated *prescriptive theories* and models set out goals and procedures as means for accomplishing ends.

These terms can be applied to instruction and to instructional-design theories. *Learning theories are descriptive theories* that propose how learning occurs and identify concepts that describe the knowledge to be learned, whereas an *instructional theory* is *prescriptive* in that it sets out rules regarding effective ways of teaching knowledge/skills. An instructional design theory is a *prescriptive design* that sets out procedures for developing instruction (Bruner 1967; Reigeluth, 1983; 1989; 1999). A strong relationship exists between them, in that descriptive theories facilitate understanding of why design theories work and, in the absence of a design theory, the descriptive theory helps the practitioner to select instructional methods that meet the given needs (Reigeluth, 1983; 1999). A theory of instruction must be congruent with those theories of learning and development to which it subscribes (Bruner, 1967). Design theories, which are inherently goal-oriented, are different from general perceptions of a theory. Most theories are descriptive, setting out cause-and-effect relationships. Design theories, however, are prescriptive, in that they offer guidelines for attainment of a stated goal. In the case of instructional design and the social sciences, the guidelines do not specify precise details. Detailed prescription occurs in the domain of deterministic or positivist theories, such as engineering or architectural design (author's examples).

There is no rigid dividing line between learning and instructional theory, and between the descriptive theories and prescriptive practices, summarized in Table 3.1. Cognisance of these concepts, however, sets a context for studies such as this, permitting the researcher to view educational technologies and learning environments as manifestations of underlying philosophical and psychological foundations.

Table 3.1 Descriptive theories and prescriptive practices

Natural sciences	Laws of nature (physics, astronomy, botany, etc.)	Descriptive theories (laws and relationships)	Learning theories (descriptive - how people learn)
Design sciences / sciences of the artificial	Man-made disciplines (medicine, instruction, architecture, etc.)	Prescriptive theories (designs, models, and guidelines)	Instructional-design theory (prescriptive practices)

Progression from theory to practice

The progression below proposes a sequence as perceived within which traditional ID originated:

Learning theory ==> instructional theory ==> instructional design/strategies ==> the practice/delivery of instruction and assessment

Wilson (1999) notes how learning theories emerge from psychology and give rise to instructional theories. These in turn are applied to the design of instruction, which informs practioners how to execute good instruction. The sequence is no longer as rigid, as will become evident in subsequent parts of this chapter. Moreover, in certain situations, such as in the researcher's homeland of South Africa, the roles of instructor and designer frequently merge - being one and the same person - resulting in flexibility and fusion of design and delivery.

Grounded design

There is a distinction between instructional and learning materials. Not all learning materials are instructional materials. Constructivist products are particularly geared towards learning rather than instruction - learning implemented by various methods and frameworks. In the context of learning materials, *grounded-learning systems design* is defined as the systematic implementation of processes and procedures rooted in established theory and research in human learning. Practitioners of grounded design recognize the value of various approaches and perspectives, synthesizing across and recognizing distinctions between, different theoretical perspectives on learning (Hannafin *et al*, 1997).

Grounded design can be applied to any learning theory platform as well as cross-platform, because it does not promote any single theoretical stance or practical methodology over another, but aims for alignment of the underlying principles and practice of learning. The four conditions for a design to be considered grounded (Hannafin *et al*, 1997) are:

1. It must be based on a defensible theoretical framework that can be differentiated from others. Multiple frameworks are also acceptable, provided there are connections between their foundations and that they lead to congruous methods.
2. Methods and strategies must have been empirically validated.
3. The design should be generalizable to other contexts or problems.
4. Grounded design and their frameworks are iteratively validated though successive implementation. Methods are tested for effectiveness according to their theoretical basis and the framework is refined as needed.

The defining characteristic of a grounded design is that the methods and system of design are well articulated and aligned, and **consistently rooted on an underlying theoretical framework** - be that framework from the objectivist or constructivist traditions or based on various combinations. Very different, yet nevertheless grounded, approaches are possible along the ID spectrum. The methods should be generalizable, and consistent with related research. The 'roots' of the design comprise five foundations: psychological, pedagogical, technological, cultural, and pragmatic.

3.2 Behaviourist instructional systems

This section overviews applications, development models, and practical implementations of the behaviourist instructional theory outlined in Chapter Two, Section 2.2.

3.2.1 Introduction to behavioural instructional systems development

A major consequence of the behaviourist instructional persuasion was the advent of systematic models for the design and development of instruction - models shaped by distinctive characteristics.

Systematic linear procedures

Traditional instructional systems development (ISD) is based on the use of **systematic, linear procedures to design, develop, and validate instruction** (Hannafin, 1992; Braden, 1996). It is systematic in that it consists of a prescribed set of steps and linear due to a predetermined order for those steps. The resulting products, which usually commence with objectives and conclude with evaluation, are intended as prescriptions for learning. Despite the proliferation of models, few substantial changes occurred in ISD processes and procedures between the 1950s and the 1980s, although computerized delivery of instruction became a feature of the latter part of this period.

Behaviourist bias

The major principles of traditional ID are derived from Skinnerian psychology (Skinner, 1938) and Gagné's conditions of learning (see 2.2.3.2). Winn (1990) traces how ID was shaped by the behavioural sciences during its formative period. Learning is believed to occur when **behaviour changes as a result of instruction** in which reinforcement and correction **guide learners towards defined goals**. An underlying principle is the stimulus-response (S-R) association, usually implemented during practice. Behavioural theory presents prescriptive principles regarding which instructional strategies to use to build and strengthen S-R links. Jonassen (1991b) points out the behaviourist bias of instructional systems theory and instructional systems technology (IST), evidenced by aspects such as task analysis, learning objectives, and criterion-referenced evaluation.

Who does what?

Instruction developed according to the principles of traditional ISD typically includes a range of instructional sequences and activities - instructional events, questions, assessment, etc., organized around educational goals. The purpose is not to limit the role of educators in disseminating knowledge, but to provide methods and activities they can use to foster understanding and introspection on the part of learners (Hannafin, 1992). Instruction is delivered by a teacher, instructor, or trainer - depending on the context, but instructional designers typically define both the content and the delivery methods.

Delivery media

ID as such refers to the process of designing and developing instruction, and need not necessarily specify the medium. The first true forms of technological instruction systems, the programmed instruction (PI) systems in the 1960s, were an implementation of operant conditioning in which learners' behaviour was moulded by reinforcing desirable responses. Subsequently, computerized instructional technology merely accommodated the standard features, and although computer-aided instruction (CAI) changed the medium of presentation, the instructional methods remained constant.

3.2.2 Characteristics of behaviourist instruction

Certain characteristics and features are clearly evident in instructional approaches and materials developed according to philosophies of science from the behavioural family - including the objectivist and empiricist views. This section lists some of the foundations of behaviourist products.

3.2.2.1 Fleming and Levie's behaviourist principles

Behaviourist instruction typically evidences stimulus-response patterns. Fleming and Levie (1978) investigated behaviourist perception principles, which in turn lead to practical behaviourist learning principles. Both sets of principles follow, under the same structured ordering:

1. ***Behaviourist perception principles*** (Fleming & Levie, 1978):

- *Physical aspects of stimuli:*
  - The spatial and temporal arrangements of stimuli influence the speed and accuracy of reception. The simplest perceptual organisation is figure-and-ground.
  - A change in stimulation helps to sustain attention.
  - The human learner can absorb only a limited amount at a time.
- *Content aspects of stimuli:*
  - The more familiar a message, the more readily it is perceived; but on the other hand, attention is drawn to what stands out as novel.
  - The amount processed depends on the number of discrete objects or events, and on the depth to which each is processed.
- *Affective aspects of stimuli:*
  - A moderate degree of uncertainty or anxiety is a strong incentive to resolve a problem.
- *Human aspects of response:*
  - Perception is organised - humans perceptually construct relationships, groups, objects and events, and partition information into chunks or clusters.
  - At one glance humans can perceive up to about seven items.

- The more accurately an object or event is perceived, the more feasible and reliable the further processing will be, such as recollection and problem solving.

*2 **Practical behaviourist learning principles*** (Fleming & Levie, 1978):

- *Physical aspects of stimuli:*
  - The association of objects or events with each other is facilitated when they are encountered in spatial or temporal contiguity.
  - Familiar or attention-gaining cues facilitate learning.
  - Learning is influenced by the frequency with which stimuli are encountered and the same responses made.
- *Content aspects of stimuli**:***
  - Introduction of material at the start of a unit facilitates subsequent learning of detail.
  - The more meaningful the relationship between items to be associated, the greater the learning. Well-organised, structured material facilitates knowledge acquisition.
  - Spaced practice is more effective than massed practice.
  - Problem solving is aided by situational support that emphasizes vital elements, reveals important relationships, and provides an opportunity to manipulate alternatives.
- *Affective aspects of stimuli**:***
  - Learning depends on its consequences - when consequences are explicitly or implicitly rewarding, learning is faster and retention is stronger.
  - The more motivated the learner, the greater can be the size of an instructional unit.
- *Comprehension and learning are facilitated by:*
  - Prior learning of related concepts,
  - Questions inserted within instruction,
  - Learner-activity and involvement, and
  - Variety in the examples and non-examples.
- *And finally, the two principles most intrinsic to behaviourist learning:*
  - Reinforcement after an act strongly affects the likelihood of that act being repeated in the same context, i.e. the likelihood of associating a stimulus and response depends on the consequences.
  - During initial learning, it is desirable to reinforce all correct responses. Subsequently, fairly frequent feedback is preferable for consolidation and maintenance of behaviour.

3.2.2.2 Hannafin and Peck's behaviourist principles

Hannafin and Peck (1988) derive four instructional design principles from behavioural learning theory:

1. *Contiguity*: The response should follow the stimulus without delay.
2. *Repetition*: Practice strengthens learning and improves retention.
3. *Feedback and reinforcement*: Knowledge of the correctness or incorrectness of a response contributes to learning.
4. *Prompting and fading*: Learners should be guided to the desired response under decreasingly cued conditions.

3.2.2.3 Gropper's behaviourist skills

Gropper (1983) lists certain intrinsically behaviourist skills to be instilled in learners by instruction. Instructional designers should provide instructional events and practice opportunities that facilitate acquisition of these skills:

1. *Discrimination*: The competent performer must be able to discriminate between one stimulus and another, and produce the appropriate response for each.
2. *Generalization*: This occurs when learners recognize analogous stimuli, and can transfer the same skill to appropriate new situations.
3. *Association*: The ability to distinguish between stimuli is not sufficient for mastery performance. The correct response must be associated with each stimulus.
4. *Chaining*: Successful performance in an activity comprises learning all the S-R units that comprise it and integrating them into a composite chain.

3.2.3 Behavioural instructional systems development models

The previous section describes characteristics of behaviourist instructional systems. Associated with this kind of instruction is a particular family of linear development models. Despite proliferation and variety, they have certain key features in common. This section outlines the strategies suggested by Gagné's events of instruction in order to achieve external learning conditions, and then introduces the phases and features of three systematic instructional design models.

3.2.3.1 Gagné's events of instruction

Gagné's categories of learning outcomes (Gagné, 1985) are listed in 2.2.3.1, along with their associated conditions of learning in 2.2.3.2. Desired learning outcomes can be used as instructional goals, each requiring different conditions in order to occur. Instruction must be designed to attain these goals. Gagné proposed nine *events of instruction* - strategies that designers can use in order to provide external conditions of learning (Gagné & Glaser, 1987; Gagné, Wager & Rojas, 1991):

1. Gaining attention;
2. Informing learner of lesson objectives;
3. Stimulating recall of prior learning;
4. Presenting stimuli with distinguishing features;
5. Guiding learning;
6. Eliciting performance;
7. Providing informative feedback;
8. Assessing performance; and
9. Enhancing retention and transfer.

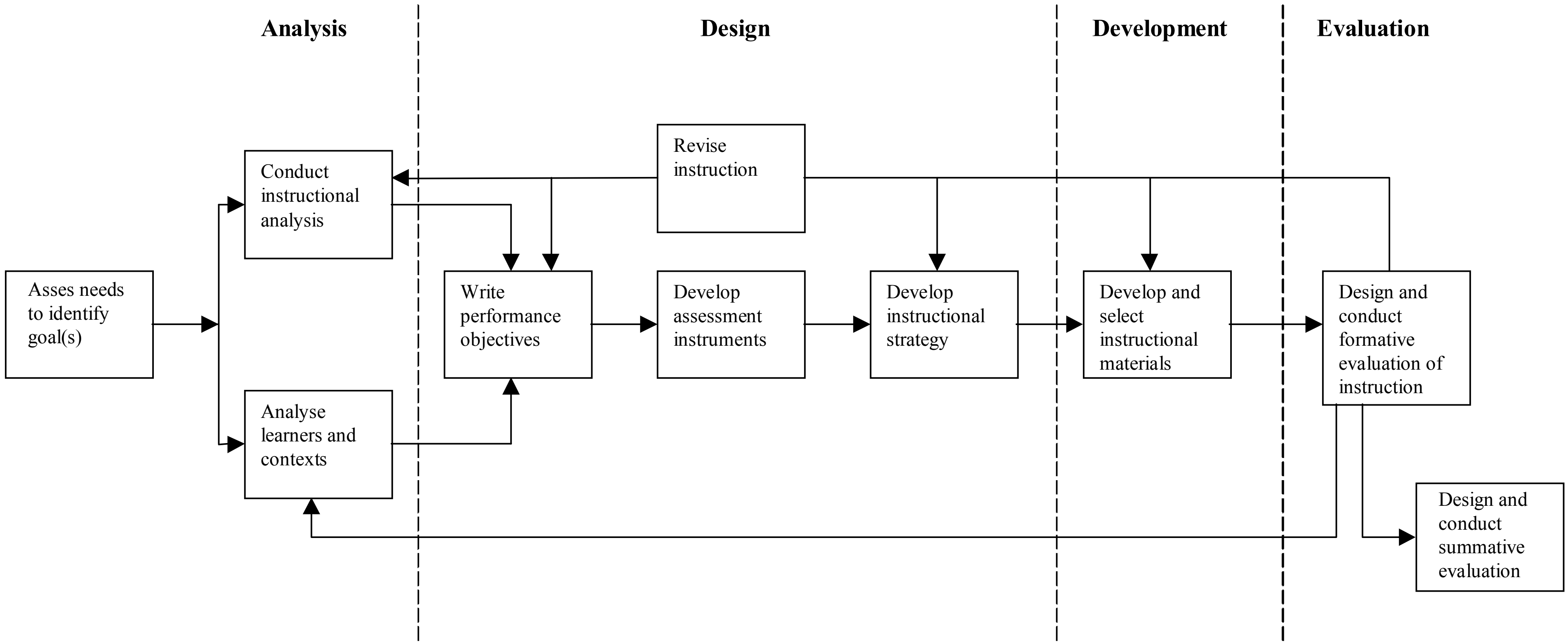
Not all of Gagné's instructional events are applicable to any given situation. Designers must select appropriate events and gear their concomitant procedures to the desired learning outcome/s.

3.2.3.2 The Dick and Carey model

Instructional design practice has been strongly influenced over the past three decades by the classic *systems-approach model* of Dick and Carey, the first of the three structured ISD models considered in this study. The first public version of the Dick and Carey model was developed in 1968 from a background of Skinnerian programmed instruction, and was the basis of Dick & Carey's classic text, *The systematic design of instruction* (1978), which is widely used in practice and as a textbook. Over 30 years the model has undergone evolutionary changes (Dick & Carey, 1978; 1985; 1990; 1996), which are particularly evident in the fourth version, shown in Figure 3.1 (Dick & Carey, 1996). This version does not predate the other models shown in 3.2.3.3 and 3.2.3.4, but the Dick and Carey model is considered first, due to its key role in systematic ISD. Actually, the version in Figure 3.1 is **not** a pure implementation of behaviourism - it even incorporates influences of constructivist theory (Dick, 1996). Notable points of the model, depicted in the diagram, are:

- Initial analysis occurs (but is not termed 'entry-behaviour identification', as in former versions).
- Identification of goals, learner- and context analysis, and setting of performance objectives occurs at an early stage.
- Assessment instruments are set up prior to development of the instructional strategy. This ensures that the instruction is correctly focused and that objectives, instruction, and assessment are in congruence with one another (note: the fourth version makes no mention of 'criterion-referenced' testing).
- Each and every stage of the instruction is part of an iterative cycle of revision; both the formative and the summative evaluations are also part of a continuous feedback and modification process.
- Dick (1996) views context as of utmost importance and the model aims for instruction that leads to satisfactory on-the-job performance and transfer of skills. To this end, formative evaluations are conducted in the workplace and clients are involved in the development of instruction. The perceptions of the client are critical in the determination of quality of an instructional programme; they must be involved right from the needs-assessment process through to the determination of solutions to the problems identified.
- Finally, summative evaluation is viewed as part of the instructional design model, and not as a separate subsequent event.

Figure 3.1 The Dick and Carey instructional design model
(Dick 1996: 2,3)



3.2.3.3 The Briggs and Wager model

The second model, the Briggs and Wager (1981) model, is a systematic instructional design model with a clear behaviourist flavour. It specifies distinct stages of design and development:

1. Assessment of needs, goals, and priorities.
2. Assessment of resources and constraints.
3. Identification of curriculum, course scope, and sequence.
4. Determination of overall structure of courses.
5. Determination of sequence of units and specific objectives.
6. Definition of performance objectives.
7. Preparation of assessments of learner performance
   (tests prepared immediately after definition of objectives).
8. Designing detail content of lessons and materials:
   - a) instructional events
   - b) media
   - c) conditions of learning

   (similarly, done after objectives).
9. Development of media, materials, and activities.
10. Formative evaluation.
11. Field tests, training, summative evaluation, and implementation.

3.2.3.4 The Braden model

The third and final ISD model is that of Braden (1996), who set up a comprehensive linear design model, which incorporates steps similar to those of the Briggs & Wager and Dick & Carey models, introduced in the previous subsections, but with three distinguishing features:

- It sets ID in an organizational context, indicating project-management and implementation-of-instruction functions which are external to the processes of design and development.
- An expanded evaluation component is provided, namely, top-to-bottom formative evaluation, i.e. there is ongoing evaluation after each stage of the process, with the ensuing revision feeding into each and every step. This occurs over and above the ultimate summative evaluation.
- A parallel juxtaposition of design and motivation stresses the importance of applying Keller's motivational model (Keller & Suzuki, 1988; section 2.5.3.2) throughout instruction.

3.2.4 Discussion of behaviourist instructional design

From the features and models described, it is clear that much of general instruction incorporates the rudiments of behaviourism.

CAI software

In particular most CAI software has behaviourist features (Gropper, 1983; Poppen & Poppen, 1988). Entry-skills analysis is used to branch to a section of the lesson appropriate to the student's level. Programs with a linear structure are sequenced in steps of increasing difficulty. A keystone of behaviourism is the provision of prompts or cues to promote correct responses, with strong cues early in the shaping processes, followed by gradual fading. Complex repertoires can be built out of subskills by shaping and chaining. An important aspect of behaviourism is its goal of automaticity in subskills (introduced in 2.3.3.6), intended to facilitate the subsequent acquisition of composite skills. **Evaluation of student-responses and the provision of immediate feedback** are important characteristics, and should supply reinforcement for correct answers and corrective or remedial feedback for inappropriate or incorrect answers. Furthermore, most conventional CAI is program-controlled, which corresponds to the instructor-centric approach of behaviourist instruction.

Objectivist design

Instructional design in the United States of America, where instructional design is a major discipline in its own right, originated with objectivist traditions. Objectivism - defined in 2.2.4.1, holds that there is *objective reality* - that the world is structured in terms of entities, properties, and relations. An objectivist approach to ID addresses *entry behaviour* prior to instruction, specifying what learners need to know or be able to do, in order to successfully complete a given learning task. Objectivists also analyse the content area to identify and communicate these entities, attributes, and relationships that learners must know and practice until mastered.

Mastery

Mastery learning is an implementation of behaviourism. The learner is given as much time as required to achieve a given level, called *mastery level*, in each instructional unit before proceeding to the next. The goal of this strategy is for all learners to achieve specific performance objectives, but it does not appear to significantly reduce individual differences in general academic performance. For determination of mastery, a test is used to determine whether the appropriate knowledge has been acquired. The learner's actual activities in the process of learning are not assessed.

Reductionism

Reductionism, defined in 2.2.4.3, is a further inherent aspect of the behavioural approach. The outcomes of instruction are considered to be observable behaviours, and these outcomes are analysed to determine their behavioural sub-components and sequences - evolving into a technique called task analysis. Task analysis is a reductionist approach to instructional decision-making (Winn, 1990), based on the premise that if the parts are identified, then the whole can be taught.

General

Behavioural methods of instruction may be effective for clearly defined outcomes and procedural domains, but are inadequate for broader learning. Many educators find these traditional instructional procedures rigid, and experience the limitations of systems based on externally-controlled knowledge acquisition (Hannafin, 1992). Further problems (Winn, 1990) are the **separation of design from implementation of instruction**, and the belief that if the instructional design model is followed correctly, then good instruction will ensue. For lower-level tasks and reliable stimulus-response relationships, these approaches can produce acceptable instruction, but not where S-R associations are mediated by mental activity. Where the underlying instructional approach is cognitive rather than behavioural, the designer's decisions regarding instructional strategies entail more than simply a knowledge of design techniques.

3.3 Cognitive instructional systems

This section relates to application, development models, and practical implementations of the cognitive instructional theories described in Chapter Two, Section 2.3.

3.3.1 Introduction to cognitive instruction and systems development

From behaviorism towards cognitivism ...

Established models proposed by practitioners such as Dick, Wager, Briggs, and Merrill dominated ID practice in the USA from the 1960s for the next thirty years with the initial versions of the sixties and seventies being rooted in behavioural psychology. The ISD and IST (instructional systems technology) models of the eighties and nineties were influenced by theories such as human information processing and psychological assumptions from the field of cognitive science, while yet maintaining behavioural roots. Certain models, such as Merrill's component display theory, are hard to categorize, since they reflect both behavioural and cognitive conceptions. Thus, ID models matured, but in general, the changes were evolutionary rather than revolutionary (Willis, 1998) as existing models were adapted in the light of new theories of learning and instruction.

Many educators find traditional instructional procedures rigid, externally controlled, and instructor-centred. Newer approaches emphasize the **learner's role in mediating learni**ng, with major design implications. Simultaneously, work in cognitive psychology suggests a shift of the role of the instructor and the instructional materials to become **activators of learning**, rather than mediators of knowledge (Hannafin, 1992).

Winn (1990) examines some of the impact of cognitive theory on instructional design. Behaviourism proposes that learning occurs in reaction to stimuli, rather than by mental operations. This ignores individual differences in aptitude, expectations, mental processing - in short, the factors that work against consistent responses to a particular stimulus. Nevertheless, instruction that works on one set of learners is expected to work with others. The implication for instruction is that criteria are set for acceptable performance and expected to operate effectively across the board. Cognitivism, on the other hand, works from the assumption of the **individuality of learners**.

3.3.2 Characteristics of cognitive instructional design

The cognitive paradigm led to evolution in instructional products and their development processes. Instructional approaches and materials that are developed according to cognitivist principles have an underlying ethos and certain definitive features, which are outlined in this section.

3.3.2.1 Objectives and task analysis

Objectives are a fundamental of instruction under traditional ISD, as set out in Sections 2.2 and 3.2. Braden (1996) claims that although traditional ID is influenced by psychologists such as Skinner and Mager, it is actually more procedural than behavioural, due to the influence of Gagné and Piaget. The last vestige of true behaviourism is the inclusion of specific and unequivocal objectives, making instruction and learning results-driven. Moreover, the latter variants of ID as described by Braden (see 3.2.3.4) are not simplistic - the steps are intertwined within complex systems, nor are the development processes inflexible - where appropriate, designers can use models as guidelines and deviate where required.

As instruction became increasingly influenced by cognitivism, objectives were no longer termed behavioural objectives, but rather performance objectives. However, Bonner (1988, cited in Winn, 1990) observes that instructional objectives in true cognitive task analysis are actually more content-oriented than performance-oriented, being **schematic representations of the knowledge** learners should acquire and the procedures they should apply, rather than statements of what they should be able to do. Traditional task analysis identifies behaviour that can be observed directly, while cognitive theory requires that unobservable mental tasks be analysed. For example, cognitivists identify procedures and schemata that enable correct performance, instead of defining components of the performance.

3.3.2.2 Entry characteristics

Cognitive theory considers the characteristics of learners (Winn, 1990; Bonner, 1988, cited in Winn, 1990) and addresses the initial mental models and knowledge schemata they bring to instruction. Defined entry behaviours are not mandatory, allowing that a learner's prior knowledge may include relevant isolated items that are adequate foundations for the acquisition of new knowledge.

3.3.2.3 Instructional strategies

1. Winn’s comparison of traditional and cognitive strategies

Bonner (1988, cited in Winn, 1990) compares cognitive and traditional instructional strategies. The traditional approach selects strategies appropriate for the kind of learning - one kind of method is prescribed when learners memorize facts and a different strategy for teaching an intellectual skill. However, the cognitive notion focuses on learner-development of adequate knowledge structures, cognitive procedures, and mental models. Learning should therefore be designed around cognitive apprenticeship (see 2.4.5.2) and fostered within problem-solving situations.

By the 1990s the design of instruction had adopted characteristics of cognitive theory, yet its behavioural roots were evident in three important areas (Winn, 1990):

1. The reductionist premise that the parts of the whole must be identified, and if these are taught, then the whole has been learned;
2. The practice of separating design from the actual implemention of instruction; and
3. The belief that, if design procedures are correctly applied, good instruction will result.

These characteristics are not problematic where the desired outcomes are low-level skills, but are inadequate for teaching content and skills that require higher levels of cognitive processing. Cognitive theory has implications for instructional design, relating respectively to the three issues above (Winn, 1990):

1. *Instructional strategies should avoid the reductionism implicit in task analysis*:
   Learning for understanding requires integration of knowledge and skills and accretion into existing schemata. Instructional strategies should ensure that components of knowledge and skill are meaningfully re-assembled. Cognitive theory stresses the mental tasks that precede observable performance, therefore procedures that enable correct performance to occur are as important as the components of the performance itself.

2. *Design needs to be integrated into the implementation of instruction:*
   Instruction must constantly monitor and adapt to changes in learners' behaviour and thinking. This does not refer to the property of adaptivity, whereby PI and CAI tutors adapt to learners' progress by selecting from a large number of frames/rules those that are appropriate to a learner's needs or stage of progress. This adaptive branching is based on the learner's interactions with the system, and constrained by the number of frames and the power of the diagnostic algorithms. In truly customizing instruction, designers should go beyond the built-in capabilities of instructional systems and make decisions while instruction is underway. A complete theory of ID should incorporate predictive aspects, allowing new rules to be invented as needed. This is complex – necessitating a super-intelligent computer tutor or the intervention of a human tutor. In the latter case, the onus is on teachers to monitor progress through pre-designed instructional programs and intervene in the event of major problems. Such teachers should be trained in instructional design and in theories of learning and instruction, so that they can create new prescriptions when necessary. (Normally, instructional design and teaching are two separate disciplines, and practitioners of one are not trained in the other.) Alternatively, the designer should be open to unanticipated problems and monitor actual use of an instructional system after implementation.

3. *Designers should work from a thorough knowledge of instructional and learning theory, not just design procedures and techniques*:
   Instructional principles are as important as design procedures. Techniques are context-bound, whereas principles support designers in the solving of novel problems.

2. Cognitive strategies

Based on developments in the field of cognitive science and research into how the mind functions, West, Farmer, and Wolff (1991) present practical implications for instructional design. They propose specific cognitive strategies that can be incorporated into instruction to foster metacognition and facilitate the active creation of mental schemata:

1. *Chunking* - rational ordering and classification of knowledge;
2. *Frames* - matrices or grids to structure concepts, categories, and relationships - either provided by the instructor or partially developed by students themselves;
3. *Concept maps* - visual arrangements with links to represent relationships;
4. *Advance organisers* - brief prose introductions prior to new material;
5. *Metaphor/Analogy/Simile* - creative bridges to show similarity between known and new concepts;
6. *Rehearsal* - reviewing, asking questions, predicting - with learners playing an active role;
7. *Imagery* - mental visualisation as a learning aid; and
8. *Mnemonics* - artificial memory aids, for example, first letter coding.

Branscomb (1996) emphasizes the particular value of metaphors in displaying analogies for learners encountering new problems.

3.3.3 Cognitive ISD models

This section presents certain instructional design models that incorporate principles to foster cognitive learning.

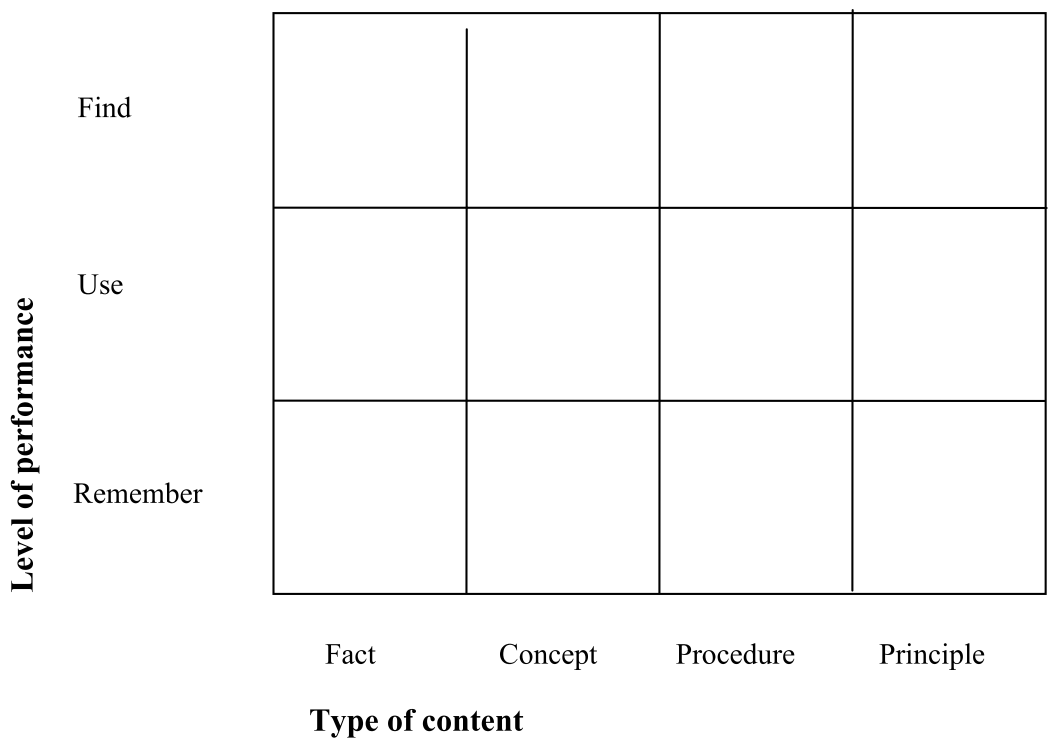
3.3.3.1 Component display theory (CDT)

Component display theory (Merrill, 1983), which was described in detail in 2.3.3.3 is briefly reviewed here, before focusing on its practical operation.

CDT is based on a set of relationships between the content to be taught and the type of performance required. Instructional outcomes are categorized on a two-dimensional matrix according to content and performance, where the content dimensions are fact, concept, procedure, and principle; and the performance categories remember, use, and find.

CDT is founded on the Gagné-Briggs prescription that there are different kinds of objectives, requiring unique conditions to promote optimal attainment. Each objective is related to the required content and to the desired performance outcome, and the corresponding instructional component is positioned in the appropriate cell on the performance-content grid, which is shown as Figure 3.2. By examining the completed grid, the instructional designer can determine how adequately the objectives have been addressed.

Figure 3.2 Merrill's performance-content grid for CDT
[Merrill 1983: 286]



CDT aims to customize instruction. Learner-control permits learners to choose from the available options, and it explicitly fosters cognitive processing by providing an environment in which learners may select both the instructional strategy and the content. In selecting the instructional strategy, i.e. the type of performance, learners control the kind of display, the amount of elaboration, and the number of examples and practice items. In selecting content components, they tackle the material most appropriate at that time.

If all the CDT prescriptions in a given lesson are implemented, the resulting instructional material would be very rich, but it is unlikely that a single student would need all the material available. It is equally probable that in a group or class each of the components would be used by at least some of the students. Thus CDT is strong on *individualization* by accommodating personal learning styles and needs, and on *metacognition* by teaching self-regulation and learning strategies.

This approach of subdividing a domain into components can be used with a wide variety of subjects and contents, and with virtually any delivery medium. However it is highly compatible with computer-aided instruction, and the second case study in Chapter Five describes an application of CDT in an interactive practice environment,

CDT facilitates the development of accurate connections within learners' mental models by emphasizing relationships within the content domain. Five major types are identified:

- Identity (the 'isa' relationship),
- inclusion (the 'is part of' or subset relationship),
- intersection (the 'and' relationship),
- the order relationship, and
- the causal relationship.

3.3.3.2 Another perspective on components

Recognising the utility of the term 'components' in a different cognitive context, Reigeluth (1999) views instructional methods as being componential when they comprise various features. For example, a comprehensive, holistic learning framework may incorporate aspects such as:

- Identification of learners' goals;
- Presentation of a scenario;
- Examples;
- Demonstration;
- Linking of new concepts to prior knowledge;
- Relating a new procedure to familiar principles;
- Practical processes such as formation of teams; and
- Providing infrastructural support for learning activities.

All of these are parts, or components, of an extensive, general method and an integral part of most learning experiences.

3.3.3.3 Enterprise schemas

The concept of enterprise schema theory (Gagné & Merrill, 1990) was introduced in 2.3.2.3, and its practical ramifications are outlined in this section.

Enterprise schemas are relevant to situations where multiple learning objectives are integrated in a comprehensive activity, and enterprise schemas must be learned. The schema initially identifies the intellectual skills and verbal knowledge that relate to the composite goal, the context or scenario that is to be played out in conducting the enterprise, and relevant problem-solving strategies. These individual items of knowledge and skill become part of the scenario as their sequence and purpose unfold. Integrative goals do not replace single instructional outcomes (e.g. facts, concepts, rules) - rather, they incorporate them as parts of the more complex activity. Various categories of integrative goals are appropriate for different enterprise schemas, namely:

- *Denoting*: which incorporates naming, labeling, concept identification, classifying, and descriptive functions;
- *Manifesting*: making a sequence of events evident to other people, demonstrating composite processes, describing procedures that exist externally to the learner, diagramming, following a procedure, and identifying concepts;
- *Discovering*: problem solving, application of cognitive strategies, and discovery-learning – all founded on intellectual skills using concepts and rules. It also involves transfering familiar entities and rules to different enterprises and applying them in new ways.

A focus on enterprises impacts on instructional practice, and leads to significant changes in instructional strategies. Traditional instructional design methodology focuses on components such as generalities and examples, as it aims to attain single objectives. On the other hand, the consideration of enterprises as integrated wholes, focuses on learners interacting holistically with the subject matter, undertaking *instructional transactions* as described in the following sections.

3.3.3.4 Second generation instructional design (ID_2)

The need for reform within instructional design theory was explained in 2.3.3.5, describing how Merrill, Li and Jones (1990a; 1990b; 1990c) set out to produce an improved methodology and tools to address shortcomings, and to guide the design and development of high quality, interactive, technology-based instructional materials. Considering Gagné's conditions of learning and CDT as first generation theory, they proposed second generation instructional design (ID_2) to represent and guide the development of instruction that would teach integrated sets of knowledge and skills with inherent interrelationships, as described in 3.3.3.3. The system should also be versatile, so as to incorporate new knowledge.

ID_2 is intended to operate as an expert system, i.e. a knowledge-based decision-making environment that lends itself to the automation of instructional design. Its architecture comprises:

- A theoretical base that organises knowledge about instructional design and defines a methodology for carrying out instructional design;
- A knowledge base that contains domain knowledge in the realm of instructional decision-making;
- A series of intelligent computer-based design tools for knowledge acquisition, strategy analysis, and transaction generation;

- A collection of 'mini experts' - distributed rule-based expert systems, each having a small knowledge base relating to a particular aspect of ID decision-making;
- A library of instructional transactions for the delivery of instruction, and the capacity to add new or existing transactions to the library; and
- An online intelligent advisory program that dynamically customizes instruction during delivery, using input from a mixed initiative dialogue with the student.

The feature that distinguishes ID_2 from other design methodologies is *knowledge representation.* Founded on the assumptions listed in 2.3.3.4, the knowledge base acquires and stores knowledge relating to course content and course delivery. The structures for knowledge organisation are called frames and the relationships are indicated by links called elaborations.

There are three kinds of frames:

(i) Entities - to represent things, e.g. a device, object, person, or symbol;
(ii) Activities - sets of related actions that the learner performs; and
(iii) Processes - sets of related actions that are external to the learner.

The set of elaborated frames is an elaborated frame network, comprising three kinds of elaborations:

(i) Components (for each kind of frame) - the components of an entity are its parts; components of an activity are steps; and for a process, the components are events and causes;
(ii) Abstractions - implemented within a class/subclass hierarchy that classifies the various frames according to 'kind-of' relationships; and
(iii) Associations - meaningful links between frames in the network.

Information moves through the network, so that data impacts on related data. The two major 'kind-of' relationships (see (ii) above) are:

(i) Inheritance - by which attributes of a class or superclass are inherited by a subclass or instance; and
(ii) Propagation - in which the contents of a frame influence another frame connected to it by an association link.

3.3.3.5 Instructional transaction theory (ITT)

Using the concepts of ID_2, described in the previous section, Merrill and the ID_2 research group (1996a; Merrill, 1997; 1999) set out to extend them and to specify their rules so that they were sufficiently complete to drive a computer program. ITT, which was introduced in 2.3.3.5, is the computer implementation of conceptual ID_2. It proved itself to be a robust representation scheme for automated knowledge analysis. The term *instructional transaction* relates to a set of components comprising the interactions necessary for a learner to acquire a particular kind of knowledge or skill.

ITT is founded on automated knowledge representation techniques, so that a generic expert system can be used to develop instructional systems in different domains by using knowledge representation techniques to store relationships between the domain objects. Instructional design is labour-intensive, so the purpose of ITT was to facilitate much of the instructional design process by setting up a content-independent shell. A general-purpose inference engine has the ability to manipulate and present the knowledge of a variety of domains according to its inbuilt instructional strategies.

Knowledge is represented in ITT using the three types of knowledge objects introduced in ID_2: entities, activities, and processes. A knowledge object is a set of predefined elements, each of which can be instantiated by means of multimedia or by a link to another object. Similarly, the descriptive theory of knowledge identifies inter-relationships between these knowledge objects, including component relationships, properties, abstraction relationships such as subclass-of or instance-of, and association relationships between entities, activities, and processes. The theory is synthesis-oriented (Merrill, 1999), emphasizing the integration of the components into instructional transactions.

Instructional transaction theory is based on the assumption of implementation by an algorithmic computer program, rather than a frame-based authoring system. With a frame-based approach, there is a tight coupling between the subject matter and the strategy, whereas an algorithmic program is subject-independent, treating the subject matter as data. The program reuses the same algorithm with different data, and can be used to implement instructional systems with varied content and in different subject-matter domains. An instructional transaction shell is a computer program that encapsulates the conditions for teaching a given type of knowledge. The subject matter can be specified without considering the instructional strategy and then the same matter can be used in a number of different instructional strategies available within the computer program.

3.3.3.6 Alternative views to linear ID - 'design alternatives'

The procedural design models described in 3.2.3.2, 3.2.3.3, and 3.2.3.4 were one of the root causes of the ID schism during the 1990s. Dick (1991; 1996) addresses the issue directly, accepting that despite the popular use and broad acceptance of the Dick and Carey model (Figure 3.1), there are those who differ on a fundamental, philosophical level. Proponents of the constructivist paradigm view the model as a pure implementation of behaviourism - an example of an objectivist approach - and challenge instructional designers to reconsider their underlying theories. Constructivists object to pre-specified objectives and criterion-based assessment. By contrast, they support contextualized learning environments in which learners explore and set their own goals and are assessed by inspection of their portfolios and project-based learning. This type of learning, investigated in-depth in Section 3.4, tends to be the antithesis of the direct instruction generated by traditional ID models.

Braden (1996:14) joins the debate, acknowledging the controversy over *objectives and objectivism, behaviourism, reinforcement, programmed instruction, criterion-referenced assessment,* and *systematic design.* He lists six *design alternatives* that challenge linear ID, along with their respective proponents. Though not limited to the cognitive view, three of the six are relevant to this section on the role of cognitive learning within the overall paradigm shift, namely Braden's so-called:

- *Charles Darwin designers* (evolutionary designers)
  This incorporates practitioners such as Merrill, Li, and Jones (1990a; 10990b; 1990c), Merrill & the ID_2 research group (1996a; 1996b) - see 2.3.3.4, 2.3.3.5, 3.3.3.4, and 3.3.3.5 - who strengthened and evolved the ID process by creating automated instructional design systems primarily to produce computer-based instruction.
- *Satre-Heidegger philosopher-designers* (constructivists, postmodernists, and critical theorists)
  Among others, this includes leading constructivists whose ethos is described in Section 2.4.1, such as Duffy and Jonassen (1991a; 1991b). Their constructivist stance is so radically different that Braden (1996) doubts its coexistence with classic ID. The debate goes beyond the shift in psychological theory from behaviourism to cognitivism and impacts on the fundamental nature of learning and instruction. Constructivists believe that individuals construct their own meaning - an internal representation of knowledge and a personal interpretation of experience. According to Braden, this conflicts with the traditional view of instruction designed to teach knowledge and learning fostered by external teaching: 'Do constructivism's basic tenets spell doom for instruction as we have known it?' and ' ... widespread acceptance of radical constructivism would mean the demise of instructional design and development' (Braden, 1996:17).
- *Jesse designers* (radicals, named for Jesse Helms and Jesse Jackson, who make no compromises!)
  Braden (1996) defines this category to incorporate theorists whose viewpoints tend to the extreme philosophical position in either of the polarised camps. As representatives of the revolutionary, anti-linear ID extreme he nominates Willis (1995; 1998; 2000) and Rowland (1995) who see no redeeming qualities in any aspect of linear ID - see 3.4.2.5 and 3.4.3.1. At the other pole, as a proponent of linear instructional design, he positions himself. Strong feelings exist in both camps. Willis and Rowland, both nominated by Braden as *Jesse designers*, express their opinions: Willis (1995) questions whether there can be interaction or a rapprochement between educational technologists representing the different sides; Rowland (1995:20, cited in Braden, 1995) asserts, 'I am forced to conclude that ISD may be helpful, but it is insufficient and apparently unnecessary'. With this background, Braden suggests that there may be no common ground between the stances. From the pro-linear pole, he argues that although the design of instruction should, and does, accommodate shifting paradigms and learning theory, linear instructional design remains relevant and necessary.

3.3.4 Cognitive-related aspects: practical applications in ISD

Cognitivism has further implications for the design and development of instructional systems. The cognitive approach to learning is more complete than the behavioural, in that it goes beyond content-related aspects and is intended to result in instructional products that are effective in low-level and high-level learning. Instructional design to support cognitive learning stresses knowledge structures and interrelationships, links from prior knowledge to new knowledge, as well as planning and self-monitoring by learners of their learning experiences. This section briefly considers how metacognition and transfer can be encouraged in learners, then introduces the concept of instructionism from the viewpoint of grounded design, and then concludes Section 2.4 by mentioning Merrill's (2001) rating scale for instructional design.

3.3.4.1 Implementation of metacognitive strategies

Metacognition is defined in 2.3.4.3, and the concepts of low-road transfer and high-road transfer are mentioned in 2.3.4.2. There is a place for the explicit incorporation of metacognitive strategies within instruction, in addition to content knowledge (De Villiers, 1995). However, designers should ensure that the strategies incorporated do not distract or compete with cognitive resources that learners should expend on task-essential learning (Osman & Hannafin, 1992). Typical instruction tends to emphasize low-road transfer over high-road transfer activities. To alleviate this and to encourage high-road transfer, emphasis should be placed on connections that extend within and beyond given lesson information, the integration of new with existing knowledge, and the construction of relationships.

When designing instructional content, techniques can be used to activate learning strategies. Whether the strategies are implicitly incorporated or taught as an additional learning outcome alongside content teaching, they should foster metacognition in the learner. In general, the more explicit strategies are better for younger or novice learners and implicit, higher-order strategies for older learners or those with significant recalled prior knowledge.

One of the must useful metacognitive strategies is interaction between learners. Describing one's learning process, evaluating each other's performance, and providing mutual feedback - in short, articulating knowledge - serves to consolidate learning.

3.3.4.2 Instructionism and grounded design

Instructionism, introduced in 2.2.4.2, is a further concept straddling the divide between behaviourism and cognitivism. Instructionism emphasizes pragmatic methods that describe and communicate the meaning of objects and events consistently and efficiently across learners (Hannafin *et al*, 1997). Learners must be able to integrate new with existing knowledge, and to recognize, categorize, and organize objects and events by decoding their established meanings. The design of the learning systems should include mathamagenic strategies, such as cueing and amplification to aid learning.

Grounded design (defined in Section 3.1.2) is a platform-independent design implementation, rooted in established theory, which can be applied within objectivism, instructionism, and constructivism. According to Hannafin *et al*, 1997, learning systems are founded on psychological, pedagogical, technological, cultural, and pragmatic considerations. For a learning system to be effective, these five foundations must be aligned so as to maximize coincidence and shared functions. Hannafin *et al* (1997) briefly investigate instructionism with respect to the five foundations. One of the *psychological theories* that underlies instructionism is Anderson's ACT (see 2.3.1.2) which suggests that knowledge in a domain starts with declarative factual knowledge (*what*), and is followed by procedural knowledge (*when* and *how*) which requires automatic operation of the existing declarative knowledge. *Pedagogical methods* to implement ACT entail would initial learning of the declarative, knowledge, which would be identified, frequently isolated, and taught in a meaningful sequence. Learning of the factual aspects would be followed by a transition to procedural knowledge, including information as to how and when the initial propositional knowledge should be used. In line with Gagné's intellectual skills category of learning outcomes (Gagné' & Glaser, 1987), complex skills and problem solving would then be encountered, following the prerequisite lower-order skills. This is the typical method of direct instruction, founded on cognitive educational psychology that views learning as an incremental, mathagenically-facilitated process.

In the case of objectivist-instructionist learning, the *technological foundation* might well link the psychological and pedagogical foundations. For example, a computer-mediated drill might be used to generate automaticity in subskills, followed by tutorial programs to teach concepts and skills, i.e. a bottom-up components-first curriculum. The *cultural foundation* of instructivism emphasizes explicit learning objectives based on knowledge and skills that can be articulated. Progress must be evaluated and mastery demonstrated. For the fifth foundation - *pragmatic considerations*, instructionists tend to compromise between theoretically ideal solutions, available resources, and the constraints present.

3.3.4.3 Five star instructional design rating

A rating system to evaluate instructional design products is proposed by Merrill (2001). Although its main focus is to grade computerized courseware, it is also generally applicable. Termed the *5 star instructional design rating*, its criteria are fundamentally cognitive, yet also suggest hybrid requirements, ranging from behavioural/objective aspects to constructivist features. It poses criteria for five categories:

1. *Problem*:
   Is the courseware topic-oriented or presented in the context of real-world problems? This criterion investigates whether learners are engaged at the problem level, i.e. beyond the operation/activity level.
2. *Activation*:
   Does the courseware activate relevant knowledge/experience? This determines whether learners are directed to recall/relate/apply past knowledge and experience as a foundation, and/or if the instructional product itself provides such. The criterion further queries whether a diagnostic pre-test is provided.
3. *Demonstration*:
   Does the courseware demonstrate/show examples? If so, does it include examples/non-examples, demonstrations of procedures, visualizations of processes, and modeling of behaviour? The second part of the criterion investigates the nature of the guidance - whether multiple representations are used and whether the multiple approaches are explicitly compared (a constructivist aspect).
4. *Application*:
   Are learners given opportunities to practice/apply the new knowledge/skill? Objectivism is evident in the detailed questions embodied in this criterion. which investigates whether the practice/application and the post-test are consistent with the objectives - whether stated or implied. Subcriteria require that learners should be able to recall/recognise, name/describe, identify/synthesize, execute procedures personally, predict consequences, and diagnose faults. Further aspects of the criterion test whether application covers a series of varied problems, and whether corrective feedback is provided as well as context-sensitive guidance which is gradually decreased.
5. *Integration*:
   Does the courseware include techniques that facilitate integration/transfer of the knowledge/skills into everyday life? Learners should be able to demonstrate them publicly; reflect-on, discuss, and defend; and go beyond the courseware in inventing and exploring personal ways to use the knowledge/skills.

3.4 Constructivist instructional systems

Since constructivist interventions do not qualify as instruction (Dick, 1991; Reeves, 1997), the header above seems paradoxical. Nevertheless, this section investigates practical implementations originating from constructivist frameworks. It re-visits the theory of Section 2.4, and investigates the characteristics of constructivist instructional experiences, as well as implications for the design and development of constructivist learning.

3.4.1 Introduction to constructivist learning and constructivist design

> *'Constructivism is not the panacea for all of the instructional problems in education and training, no more than other theories and technologies are. Yet all are designed to make learning a more realistic and meaningful process'* (Jonassen, 1991b:11).

Traditional ISD holds an objectivist world view, based on the premise that the purpose of instruction is to transfer objective information and impart knowledge. Epistemologically this entails the direct transfer of a particular reality, without learners interpreting or reconstructing it, whereas constructivism claims that learners can only interpret information in the context of their own experience, and that learning is individualistic. The implication of constructivism for ID is that learners should be enabled to construct their own relevant and conceptually functional representations of the external world. The two approaches involve different roles for instructional designers, since constructivist learning occurs less according to a predetermined sequence of instructional events and more within supportive learning environments where tools and techniques must be provided.

This presents a conundrum to instructional designers who have been trained to ensure a common set of outcomes, yet must now support learners in individual knowledge construction (Jonassen, 1994). How can models of design be adapted for constructivist learning? The instructional design community is accustomed to *replicable methodologies* and although, by its very nature, constructivism can never be a prescriptive theory of instruction, designers would, at least, appreciate **explicit guidelines** on the design of environments that foster constructivist learning.

3.4.1.1 Differences between assumptions of traditional ID and constructivism

Winn (1992) highlights three differences between the basic assumptions of traditional ID and those of constructivism, which lead to a reconceptualization of the design of instructional experiences:

1. *Emphasis on learning, rather than on performance and instruction*

   Behavioral ID assumes that instructional models and strategies can be used to bring about predictable change in students' knowledge and skills, evidenced by their performances. This works well for basic knowledge in relatively structured knowledge domains. But much of what must be learned entails advanced knowledge in complex, ill-structured domains, where behaviour cannot be predicted, nor acceptable performance be precisely defined. Under constructivism, students select or develop their own learning strategies and often their own goals/objectives. Instead of prescribing instructional strategies, the designer guides or coaches as the need arises, but does not impose a particular way to learn. Students carry much of that responsibility themselves. This emphasis on learning requires designers to reason from knowledge of how people think and learn, rather than systematically applying the procedures of an ID model.
2. *Different role for technology*

   Once instruction is designed, it must be delivered. ID is so closely associated with educational technology that instruction is often designed for delivery via specific technology. **Instead of using technology to teach content, constructivists use it to promote learning.** *Full* technologies are systems that contain information to be transferred to the student (e.g. CAI and ITSs), while *empty* technologies are shells or tools that allow students to explore and construct (Zucchermaglia, 1991, cited in Winn,1992).
3. *Different approach to design*

   Since there is little emphasis on instruction and performance, and delivery systems do not deliver content, what remains for the constructivist designer to design? First, to continue designing instruction in basic knowledge in well-structured domains, since learners must have some knowledge from which to start construction. Second, shells must be designed to support learners as they construct meaning. This means that selection of strategies and even of content occurs at the time of learning and is not pre-decided by a designer. By shifting instructional decisions to the time of delivery, the design of instruction is re-integrated with its implementation.

The constructivist debate initially promoted **principles** of constructivist learning, but fell short in proposing **practical approaches**. By the mid-1990s, however, constructivism was impacting on educational practice with the emergence of constructivist design (C-ID) models. Their advent generated considerable discussion within the USA's ID community, as professionals such as Braden, Merrill, Dick, Willis, and Reigeluth examined these alternative models, producing a significant body of literature on the relative merits of traditional procedures and the new frameworks.

3.4.1.2 Towards constructivist instructional design

Bednar *et al* (1992) present the background to instructional design from a constructivist viewpoint:

1. *Analysis of content*

   Content cannot be pre-specified, since learners must construct their understanding. A core body of information may be specified, but the student is encouraged to search for other relevant knowledge domains and viewpoints. Constructivists believe that learning cannot be defined independent of its content/context. Facts are not simply information to be remembered in isolation, but **knowledge to be applied in real life contexts**, helping learners to think as experts in that domain. For example, in geography, the goal should not be to teach facts or principles, but to teach students to use geographic information like a cartographer or navigator, although it may not be possible to start with an authentic task. Just as different experts bring new perspectives to bear, identify different relevant information, and come to varying conclusions, so too must the identification of information and 'correct' solutions be open in an instructional situation.

2. *Analysis of learners*

   In traditional instruction, the general learner or pool of learners, guides the design of learning materials. Constructivism, however, concerns itself with each learner's unique perspective. Furthermore, the focus is on skills of reflexivity (mental operations – reasoning about the material in hand), not remembering. Traditional approaches stress **efficient processing, accurate storage, and retrieval** of externally defined information while constructivists focus on **knowledge construction and the development of reflexive awareness** of that process.

3. *Specification of objectives*

   In traditional ID, the analysis phase culminates in the specification of intended learning outcomes. From the constructivst perspective, the function of analysis is to characterize unique ways of knowing in each domain, teaching learners to think like practitioners of that field.

4. *Design*

   Traditionally, the design phase of ID sets out, at macrolevel, an instructional sequence to achieve specified performance objectives. This approach however, is antithetical to the constructivist viewpoint, which aims to develop learning **environments that facilitate construction of understanding from multiple perspectives**. Sequencing of instruction, external control of instructional events, and pre-defined conclusions hinder personal constructive activity and discourage development of alternative perspectives.

At the microlevel, traditional design strategies present the message - the optimal treatments - to achieve each objective. Constructivists, however, consider it inappropriate to focus attention in any manner distinct from a real-world context. Instruction is based on techniques from constructivist epistemological assumptions and learning theory, for example, situating cognition in real-world contexts, teaching via cognitive apprenticeship, and construction of multiple perspectives. A central strategy for achieving these perspectives is a collaborative learning environment, emphasizing collaboration to develop, share, and compare alternative views.

5. *Evaluation*

Evaluation of constructivist learning was discussed in 2.4.2.2. Bednar *et al* (1992) describe the practical issues in the light of constructivist ID. The constructivist goal is to improve learners' ability to use content knowledge in authentic tasks; the role of the instructor or designer is to provide the tools learners need to develop skills of constructing informed responses. Constructivist evaluation examines the thinking process and problem-solving within the content domain, thus necessitating understanding of the content. For example, learners could be asked to solve a problem in the field of content, explaining and defending their decisions, i.e. demonstrating metacognitive skills in reflexive awareness of their own thinking. Another approach is to require learners to reflect on their own learning and document the processes that they applied to the content, showing to what degree their constructed knowledge of the field permits them to function within it. Both these evaluation methods contrast strongly with the traditional mastery model. A further issue is how to operationalize these new concepts of instrumentality, since no two students would make identical interpretations, nor apply their learning in the same way to real-world problems which do not have one best answer.

3.4.2 Characteristics and principles of design for constructivist learning

As constructivism progressed from a philosophy to an instructional approach, general principles for, and attributes of, constructivist instructional design, were suggested. Examples are Lebow's (1993) constructivist values, Jonassen and Duffy's heuristics for designing general constructivist environments (Duffy & Jonassen, 1991a; Jonassen, 1994), Kozma's (2000) proposed cultural changes to educational technology research and development, and Willis' (2000) design principles. Some of these and others are discussed in this section, which traces the concretization of constructivism through its values and the advent of constructivist design up to general principles of constructivist instruction and instructional design. This serves as a background for Section 3.4.3, which presents some specific frameworks for constructivist learning and constructivist ID.

3.4.2.1 From objectivist strategies to constructivist methods

Constructivism has major implications for instructional design, in particular, in the generation of learning and instructional environments. Explicit constructivist design models are complex and unlikely, because the type of learning is context-specific. What works in one domain is unlikely to transfer to another content domain. In the early 1990s certain common characteristics were identified for constructivist instruction (Cunningham, 1991a; Jonassen, 1991a; 1991b; Bednar *et al*, 1992), which suggest significant changes to the key features of traditional ID models, such as objectives, task analysis, strategies, evaluation, and roles:

1. *Instructional goals and objectives would be negotiated, not imposed.*
   Universal objectives and explicit performance goals cannot be specified, since each learner interprets differently. Objectives could rather be used as negotiating tools to guide learners and for self-evaluation of learning outcomes.
2. *Task- and content analysis would focus less on identifying an optimal learning sequence.*
   Task analysis should focus more on providing learners with intellectual tools to facilitate knowledge construction and accommodate multiple interpretations.
3. *The goal of instructional systems technology would be less concerned with defining mathamagenic instructional strategies to lead learners into prescribed behaviours, and more with supporting learner-control of their own mental activities.*
   Instructional designers would provide learning environments with embedded tool kits to facilitate knowledge construction by learners themselves. This generative-mathamagenic distinction refers to the locus of control, in that objectivists view learning as **externally-mediated** by instructional strategies, and constructivists perceive it as **internally-controlled** by the learners themselves.
4. *Evaluation of learning would become less criterion-referenced.*
   Learners interpret differently, so evaluation of learning should be flexible, not rigid, to accommodate variety. Evaluation would also be influenced by learners' self-analysis.
5. *The roles of instructional designer and educator would converge.*
   Constructivism stresses the role of the actual educator, and the task of the instructional designer tends to be that of a consultant who provides tools and techniques to help educators accomplish their goals. Educators are responsible for developing learning and instructional situations, rather than just implementing procedures predetermined by a designer or instructional technologist.
6. *Instruction and learning should occur in relevant contexts.*
7. *Multiple perspectives are valuable.*
   Since constructivism accepts no single schema or objective reality, learning should be enhanced by presenting learners with multiple representations of the content and its themes.

3.4.2.2 Constructivist values

Lebow (1993) also investigated the implications of constructivist philosophy for instructional design. Suggesting that behaviourism and constructivism are not incompatible, Lebow proposes that traditional design principles be applied in supporting self-directed behaviour changes on the part of learners. Constructivist philosophy offers instructional designers an alternative set of values, suggesting a new mindset that may significantly influence methods, without challenging the coherence and consistency of the basic ISD model. The context of learning should stimulate cognitive activity, as learners engage in relevant problem solving. Lebow presents five principles:

1. *Maintain a buffer between the learner and the potentially damaging effects of instructional practices*.

   This entails emphasizing the affective domain of learning and making instruction personally relevant, in line with Keller's ARCS model (see 2.5.3.2). In particular, instruction should be designed to achieve a balance between:

   - external control of the learning situation, and
   - promotion of self-regulation and personal autonomy among learners.

2. *Provide a context for learning that supports both autonomy and relatedness.*

   Constructivism opposes strict sequencing of instructional events in favour of responding to needs inherent in the situation. Cognitive strategies should promote learner engagement and responsibility. The educator's role involves coached practice and scaffolding to extend each learner within his/her zone of proximal development, as is done in cognitive apprenticeship (see 2.4.5.2). The context should incorporate inter-learner collaboration and positive interdependence of learners, yet stress self-regulation and individual accountability. The support of autonomy should be in a spirit of stewardship and not extend to permissiveness.

3. *Embed the reasons for learning into the learning activity itself.*

   Learners experience much of their formal education as irrelevant and inconsistent with their worldview. Unless they grasp the significance of learning, the knowledge may be inert, leading to difficulties in transfer. To obviate this, the learning situation should promote application and manipulation of knowledge within contexts such as project-based learning (see 2.4.5.4), which emphasize authenticity. Furthermore, constructivists favour problem-solving tasks that are relevant to learners' interests and that include some of the complex attributes of real-world problems.

4. *Support self-regulation through the promotion of skills and attitudes that enable learners to take increasing responsibility for their own developmental restructuring process*.

   Traditional ISD is an empirical-rational change strategy, assuming that desired behavioural changes will occur as a result of successful execution of lesson-controlled instructional strategies. Constructivist philosophy emphasizes a different kind of change strategy - a normative re-education strategy positing that **attitudes, values, and interests of learners cannot be separated from the process of learning**. The goal of education therefore is to influence the normative orientation of learners towards self-regulatory learning and development. Learners' beliefs and mental models can change if they discover for themselves that their knowledge is insufficient to solve relevant problems, and if they develop awareness about how they learn.

5. *Strengthen the learner's tendency to engage in intentional learning processes, especially by encouraging the strategic exploration of errors.*

   Intentional learning refers to purposeful processing of information in the learning situation to achieve personal learning goals. A major difference between the systems approach and constructivist practice is the approach to errors. Within traditional ISD, errors trigger feedback in the form of remediation or additional instruction, and are also used in assessment as indicators of performance. Under constructivism, errors are viewed as **positive stimulants that create disequilibrium**, leading to self-reflection and conceptual restructuring. The goal is to avoid adversely influencing learners' self-image, and focus instead on **error-recovery procedures**. Learners are encouraged to ask additional questions, so as to improve their mental model, understand alternative frames of reference, provide bridges to new understanding, and to continue self-reflection, i.e. strategic exploration and positive use of errors. Constructivism uses errors to serve learners' interests in goal-setting and self-assessment - stressing their ability to apply and manipulate knowledge within an authentic task environment, rather than the ability to generate correct answers.

3.4.2.3 Constructivist constructs

By the mid-1990s constructivist learning was maturing, with the clear emergence of concepts such as learning environments and contextualized learning. Jonassen (1994) tentatively identified a *web of constructs* common to most constructivist projects. The elements identified are process-oriented rather than product-oriented, and are based on the three attributes of construction, context, and collaboration:

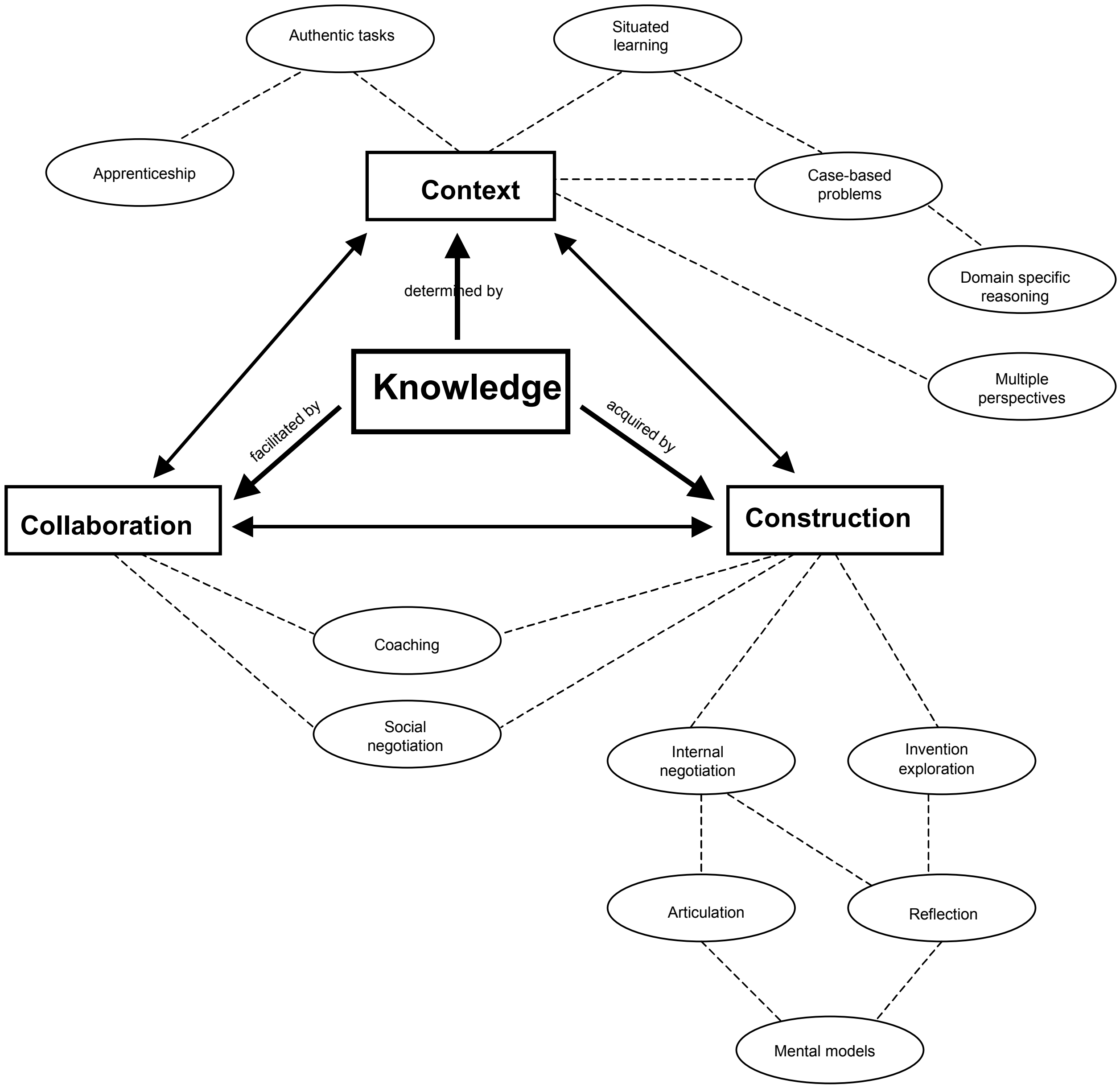
1. *Constructivist design should produce environments that support the construction of knowledge*. This knowledge is
   - based on internal negotiation by learners to produce and articulate their mental models, using them to explain, predict, and reflect;
   - supported by social negotiation; and
   - facilitated by exploration of real world environments, regulated by each individual learner.

2. *Constructivist design should provide a meaningful authentic context for learning and knowledge-construction*, which should
   - be supported by real-world, case-based problems, incorporating uncertainty and complexity;
   - require learners to demonstrate metacognitive understanding and problem-solving abilities which recognise that problems in a particular context differ from problems in other contexts.

3. *Environments designed by constructivist principles should support collaboration*.
   Collaboration should occur between learners as well as educator-learner collaboration, with the educator being more of a coach/mentor than a purveyor of knowledge. The educator should engage and facilitate social negotiation and provide an intellectual toolkit to support the internal negotiation required for building mental models.

The web of constructs and its interrelationships is shown in Figure 3.3.

Figure 3.3 Jonassen's web of constructivism
(Adapted from Jonassen 1994: 36)



3.4.2.4 Constructivist instructional principles

As constructivist concepts such as learning environments and learning via authentic tasks became established, attention focused on the role of the learner in this new-style instruction. Savery and Duffy (1995) assert that constructivist instruction should:

1. *Anchor all learning activities to a larger task or problem* - the learner must clearly perceive and accept the relevance of all specific activities in the context of the main task.
2. *Design an authentic task* - the cognitive demands of the task must be consistent with the cognitive demands of the environment for which the learner is being prepared.
3. *Support learners in developing ownership of the overall problem or task* - learners' goals must be consistent with the instructional goals.
4. *Give learners ownership of the process of developing a solution* – i.e. ownership of the problem-solving process, as well as of the problem. The educator should not dictate the process or methodology to be used for working on that problem. Pre-specification of activities will hinder authentic thinking in the domain.
5. *Design the task and learning environment to reflect the complexity of the real life environment* - rather than simplifying the environment, educators should seek to support learners in situations of complexity.
6. *Design the learning environment to support and challenge the learner's thinking* - learners should become effective and critical thinkers. Resources and materials should be used as sources of information - not to teach, but to support inquiry.
7. *Encourage the testing of ideas against alternative views and alternative contexts* - quality of understanding can only be determined in a collaborative environment where learners discuss issues and ideas to enrich personal understanding.
8. *Provide opportunity for, and support reflection on, both the content learned and the learning process* - learners should develop the skills of self-regulation and independence.

3.4.2.5 Constructivist design principles

By the end of the twentieth century, constructivist learning was increasingly implemented in learning environments and problem-based learning, as well as in situations where learners need to acquire particular skills. Willis (2000) discusses general issues and guidelines for constructivist design, principles that are used in practice in Willis' own model - see 3.4.3.1 and 3.4.3.4:

1. ***Reflection in action, rather than rule-based and research-based***

   Willis refers to Schon's (1987) concept of *reflection-in-action*, defined with relation to professionals tackling their everyday activities, and applies it to constructivist ID. Referring to the ways that practicing professionals perform their knowing- and practice situations, there are two distinct approaches (as well as the middle ground between):

   - The *technical rational* approach to practice is derived from positivist, objectivist philosophy, and classic research methodology. It involves defining a problem precisely and applying clear, well-formed solutions derived from research or recognized rules. These methods are appropriate for well-defined, tractable problems, as evidenced in the use of tried-and-true, research-proven ID techniques and strategies for direct instruction.
   - In stark contrast is *reflective* practice (Schon, 1987). Reflection-in-action relates to professional artistry - an instinctive process which defies pre-definition and plays a major part in the matter of professional competence. The territory of reflective practice is bounded by artistry; it goes beyond rules of inquiry and may result in the invention of new rules, on the spot, frequently in situations that are uncertain, conflicting, and unique. Similarly, constructivist environments are not based on precise rules and specifications - applicable to given situations, but on flexible, guiding principles to be applied in unique contexts and problems which cannot be well-formed.

   The approaches of Plato and Aristotle to knowledge are interesting analogies (Willis, 2000). The knowledge defined by Plato, *episteme,* is general, abstract and procedural, and can be said to be universal. Aristotle's knowledge, *phronesis*, depends on a context – it is practical wisdom rather than abstract universal wisdom. Traditional ID has Platonic leanings, whereas constructivist approaches are more Aristotelian.

2. ***Three first-order principles are suggested for constructivist instructional design, each having a counterpart in current research methodology or actual practice:***

   - *Participatory design* - this is one of the more controversial aspects of the alternative ID models, where the intended end-users play a vital role in designing a system. The designer is no longer the expert who knows best, but one of a team in which the end-user is a full participant alongside the expert, rather than being an object of study, i.e. it is an expert-expert model, rather than an expert-object model. Kozma (2000) refers to the involvement of students in design and experimentation. Steyn (2001) successfully involved students in the design and development of a multimedia simulation game to teach electrical concepts (see Section 2.6.4). The students who participated became more motivated, mastered new competencies, and experienced sound teamwork. Participatory design has a research equivalent in the form of qualitative research methodologies, where qualitative methods and associated paradigms are increasingly common.

- *Recursive, non-linear design* - most ID models use forms of recursion, but at specified points in the design. The idea of recursion is to address the same issues iteratively throughout the design and development process, and at many levels. The design procedures can be completed in any meaningful sequence, without a fixed beginning or end point. This is in line with the non-linearity of postmodernism (Hlynka 1995, cited in Willis, 2000).
- *Reflective design* - in the first point of this section, reflective practice was contrasted with technical-rationality. Thinking reflectively leads to reformulations of the problem as well as to experimentation, and is appropriate for constructivist ID models, which entail not only knowledge construction by learners, but also construction by ID practitioners in formulating the objects of their profession. Reflectivity occurred in Steyn's (2001) involvement of students in design (see *participatory design* above). The initial exposure to new knowledge led to disequilibrium, followed by further interaction with new information and the construction of new perceptions. The constructivist learning experience was further enhanced by achieving a real-world accomplishment, rather than test scores.

3.4.2.6 BIG and WIG constructivism

Constructivism can be implemented to varying extents (Perkins, 1991a). There is BIG constructivism, proposed by Bruner (1973, cited in Perkins, 1991a) as an acronym for 'beyond the information given'. Such an approach exposes learners to certain concepts fairly directly, then engages them in activities which challenge them to move beyond the initial information, and to generalize and refine their own understanding. By contrast, a WIG approach, 'without the information given' holds back on direct instruction. Learners can be presented with phenomena and anomalies, and encouraged to explain and model them. Scaffolding is provided but not direct information. WIG is a way of implementing discovery learning and the construction of ideas, but in the view of Perkins (1991a), would be inefficient and ineffective as the sole method of learning.

3.4.2.7 Constructivist assessment

Section 2.4.2.2 set out the constructivist approach to evaluation of learning. Constructivism decries traditional testing and criterion-based assessment, favouring ongoing assessment of activities in authentic settings. Willis and Wright (2000) suggest various alternative forms of constructivist assessment, such as *projects*, *portfolios*, *activity logs*, and the keeping of *journals*. In 3.4.1.2 the value of *self-evaluation* was mentioned, and 3.4.2.3 advocates collaborative learning and social negotiation, which can result in *peer-assessment* playing a role.

3.4.3 Frameworks for constructivist learning and constructivist instructional design (C-ID) models

Educational literature of the early 1990s abounded with articles pointing out shortfalls in the objectivist models of traditional instructional design, while expounding the benefits of constructivism and proposing that instruction be practiced from this perspective. However, there was a lack of pragmatic constructivist models that could be adopted by the ID community to implement the alternative paradigm, although various authors published general principles, on the lines of those in Section 3.4.2. Constructivist theories view knowledge and meaning as contextualized - emphasizing interpretation, multiple perspectives, and social construction of meaning. These values result in a paradox - proponents are reluctant to propose their own model as the ultimate model of constructivist instructional design (Willis 2000). However the mid-1990s saw the appearance of specific frameworks and models, for example, Cennamo, Abell, and Chung (1996), Hannafin *et al* (1997), Willis (1995), and Willis and Wright (2000). This section sets out several frameworks - in date-order, so as to trace the emergence of constructivist norms. As constructivist instructional design matured, the term *C-ID models* came into being.

Can there be an ultimate constructivist instructional design (C-ID) model? Or would it be a contradiction in terms to suggest an ideal constructivist approach to design? By its very nature, constructivism decries any single objective reality, thus excluding a single classic C-ID model.

3.4.3.1 The recursive reflective design and development model (R2D2)

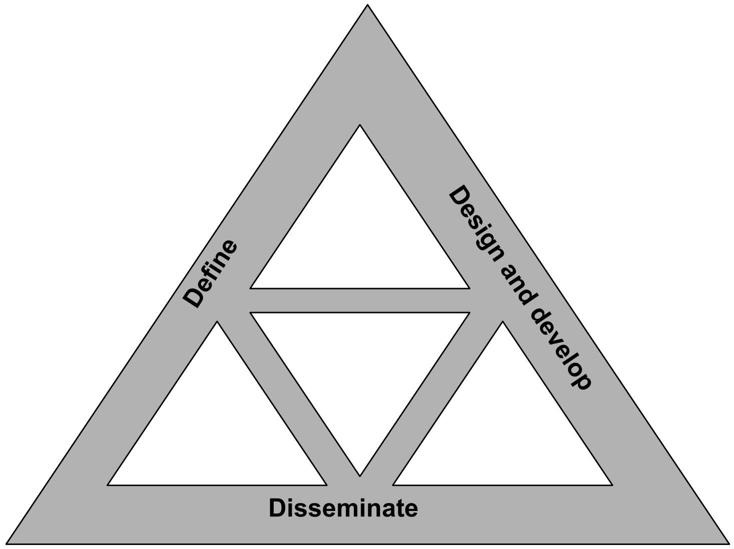
Willis (1995; 1998; 2000) who made well-formed suggestions in the Recursive, Reflective Design and Development (R2D2) model, is a pioneer of constructivist instructional design (C-ID).

The model

R2D2 is a constructivist-interpretivist approach to ID. It is constructivist in that it is based on constructivist learning theories, and interpretivist with respect to its situation within scientific philosophies, and it is an implementation of Willis' principles, introduced in 3.4.2.5, to guide constructivist design practice. R2D2 is non-linear and is based on three components and two perspectives (Willis 1995).

The three components: *define, design-and-develop,* and *disseminate,* determine three focal areas, as shown in Figure 3.4, design and develop being the sources of the two 'D's in the R2D2 acronym. The components are addressed from the perspectives of the two 'R's, namely *recursion* and *reflection*, which relate to the ways in which the instruction is developed. The figure indicates that the process has no obvious beginning or end points.

Figure 3.4 The R2D2 instructional design model
(simplified version of Willis, 1995:15)



The perspectives:

Recursion: Instead of progressing in a linear way from stage to stage, R2D2 is recursive, addressing the same issues iteratively during the process. Decisions, solutions, and alternatives emerge gradually.
Reflectiveness, The second encompassing principle, reflectiveness, originates from Schön's (1987) reflective approach to professional practice. In contrast to objectivist models, which stress the tasks done before and after the actual development of instructional materials (setting objectives and summative evaluation, respectively), R2D2 emphasizes creativity in the current context - a complex and changing situation. The *reflective practioner* (Schön, 1987) is both a participant in the process and the critic who observes and analyses. A reflective model of practice assumes that most problems in professional activities cannot be well-formed and addressed with pre-planned solutions.

The components (focus areas/points)

Definition focus:
This is based on the subtasks of the traditional ID model, but adapted:
1. Front-end analysis - evaluating the need and existing materials.
2. Learner analysis - developing an understanding of the target group. R2D2 treats learner-analysis as an on-going process, rather than a preliminary phase. Also different from traditional ISD, learner-analysis refers to learners participating in the design process.
3. Task and concept analysis - defining the skills learners must acquire. In behaviourally-based projects the content is divided into components to be taught and practiced separately, but the goal of R2D2 is to deliver instruction and promote learning within authentic tasks.

4. Specifying instructional objectives - in a traditional model this involves converting the results of the task and concept analysis into a set of objectives to guide the design process. In R2D2 the process reverses, as specific objectives evolve naturally from the participatory design in which learners and facilitators discuss the specific tasks to tackle. The overall learning task, however, is predefined.

Design and development focus:
In a traditional ID model, design tends to be completed before development (when the instructional material is actually created), but R2D2 combines the two processes into one focus area. This stage involves selection of media and format; selection of a development environment; product design and development; and evaluation strategy.
The R2D2 team do not believe that products with high user-appeal can be produced using a traditional, top-down, linear model of development. Merging the tasks of design and development reduces risk, because fundamental problems are discovered early, obviating committal to a design that cannot be properly executed. Another advantage is the opportunity for experimentation - running segments of the program with learners - and immediate revision, to see the effects of change. This enhances the quality of the end-product. In order to handle design and development in this recursive manner, an interactive development environment is required, so that the final format, content, and feel can emerge across the development process. Formative evaluation by learners, pilot-tryouts, as well as expert appraisal, are thus integral parts of design and development.

Dissemination:
In the usual ID models, this comprises summative evaluation, final packaging, diffusion, and adoption. R2D2 is similar, with the exception of its approach to summative evaluation. It is difficult to generalize the results of such evaluation, because **constructivist products are intended to be used in different ways in different settings**. Also, traditional summative evaluation tends to have an objective emphasis which is at loggerheads with the constructivist approach of personal goal-setting by learners and diverse learning activities from learner to learner.

3.4.3.2 The layers of negotiation model for designing constructivist learning materials

In the process of designing materials for constructivist learning, Cennamo, Abell, and Chung (1996) propose a general approach for the design of products consistent with constructivist ideas.

Assumptions of the model
Designing materials for constructivist learning environments implies that both the processes and the products of instructional design must be revised. Within this perspective, it is inappropriate to set learning objectives. So the authors aim to design materials guided by their assumptions about teaching

and learning, and having done so, reflect over the design process and compare the procedures with those prescribed by traditional models. The three basic assumptions were that:

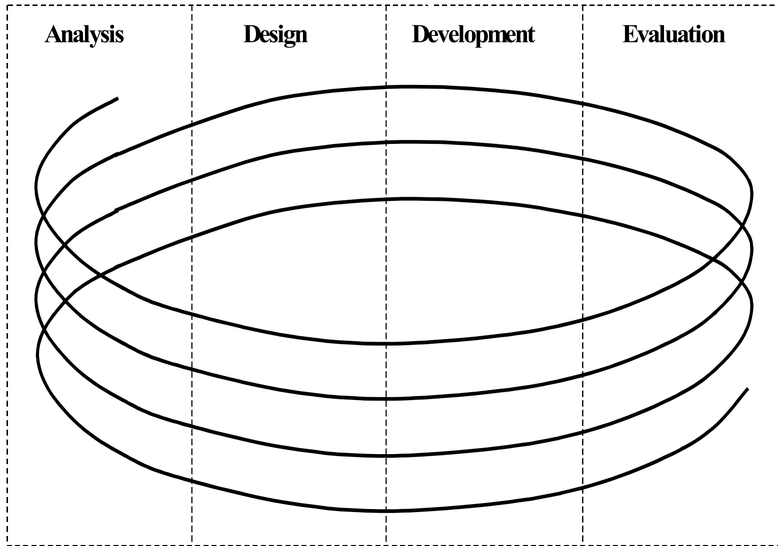
1. Learners come to an instructional setting from a wide variety of backgrounds that have shaped their understandings, beliefs and values. They derive individual meaning from an instructional experience as they mediate it through their unique filter of understanding. Learning materials must thus be capable of supporting a diversity of learners.
2. Learning is a process of assimilating new information within existing knowledge-structures and adjusting prior understanding to accommodate new information. Learners must be dissatisfied with their existing knowledge in order for further learning to occur.
3. Through social interactions learners make sense of the world. By comparing ideas and sharing knowledge with both experts and peers, learners may find new ideas that are intelligent, plausible, and useful alternatives.

Conditions to be incorporated within constructivist learning environments

Based on Driscoll's (1994, cited in Cennamo, Abell & Chung, 1996) five conditions to be incorporated within constructivist learning environments, the designers of the 'layers of negotiation model' transformed Driscoll's conditions to apply to the actual design of constructivist materials:

1. *Embrace the complexity of the design process*.
   Designers should not rely on simplified prescriptions.
2. *Provide for social negotiations as an integral part of designing the materials.*
   This entails establishing a shared perspective within the design team.
3. *Examine the information that is relevant to the design of the instruction on multiple occasions and from multiple perspectives*.
   Revisiting the same material for different purposes, in rearranged contexts and from different conceptual perspectives, results in a rich environment for learning complex skills. The product should be extensively reviewed.
4. *Nurture reflexivity in the design process.*
   When reviewing instructional materials, instructional designers and subject matter experts typically focus on varying facets of instruction and learning. Reflexivity is critical to understanding these perspectives, forcing all participants to clearly articulate their reasoning and become aware of other positions.
5. *Emphasize client-centred design*.
   Clients must be actively involved in determining their needs and how best they can be satisfied. Clients are defined as representatives of those who will ultimately use the instruction, rather than those who fund the projects. Clients are involved at each stage of the process, and able to refine their requirements as the project evolves.

Fig 3.5 The Cennamo, Abell and Chung
'Layers of negotiation' constructivist design model
(Cennamo, Abell & Chung 1996:46)



Discussion

The creators of this model did not follow a traditional model of instructional design, yet their model is indeed systematic. Although most of the systematic ID models include discrete stages for analysis, design, development, and evaluation activities, some models are cyclic. Similarly, in the Cennamo, Abell, and Chung model, design of the materials evolves in a spiral, layered fashion, as shown in Figure 3.5, proceeding cyclically with ongoing analysis, design, development, and evaluation, reaching deeper levels as additional data becomes available or relevant. The 'layers of negotiation' process differs considerably from traditional ID models. It incorporates:

- *Process-based versus procedure-based design*

Instead of prescribing a set of procedures, the emphasis is on a process of decision-making. The client-centred design entails reflexivity, as do the negotiations between the members of the design team with their initial individual sets of perspectives, values, understandings, and beliefs. A shared philosophy of learning developes as the team seek ways to assess the learners' knowledge development.

- *Question-driven approach, rather than task-driven*

Rowland (1992; cited in Cennamo, Abell, and Chung) suggests that instructional design should be based on asking good questions, rather than merely following the steps prescribed in a model. When comparing their process with the Dick and Carey model of instructional design, Cennamo, Abel, and Chung found that although they had not proceeded through the steps in a linear fashion, they had, in fact, addressed most of the questions implicit in the classic model, except those such as task analysis or predetermination of learning objectives. They had performed a content analysis, focused on various interpretations of the content, and had provided intellectual tools for learners to use in knowledge construction.

- *Spiral cycles instead of discrete stages*

The layers of negotiation model addresses design questions in a spiral fashion, progressing through the knowledge-building cycles iteratively, adding more depth and detail on successive levels. Unlike traditional models - where there are separate stages for activities such as design, development, and evaluation - the negotiation layers are not distinguished by the type of task, but by the level of complexity and amount of data incorporated at each level.

3.4.3.3 Constructivism and grounded design

Grounded design (Hannafin *et al*, 1997) is defined in the terminology section, 3.1.2 and is applied to instructionism in 3.3.4.2. In this section, it is applied to determine what characterizes a grounded constructivist learning environment.

For constructivists, objects and events have no absolute meaning, since individual meaning is constructed and assigned according to personal experience and interpretation. Constructivism downplays subdivision into component parts, favouring environments that incorporate knowledge, skill, and complexity and contexts within which learners can negotiate meaning.

Learning systems are founded on psychological, pedagogical, technological, cultural, and pragmatic considerations (Hannafin *et al*, 1997). For a learning system to be effectively based on a grounded design, these five foundations must be aligned so as to maximize coincidence and shared functions. Constructivist learning environments are examined with respect to the five foundations of the grounded design framework:

1. The *psychological foundations* of constructivism are theories such as situated cognition (see 2.4.5.1) and socially shared cognition. These concepts promote learning in realistic, complex contexts that use knowledge and skills in appropriate circumstances.

2. A *pedagogical approach* consistent with constructivism is anchored instruction (see 2.4.5.1), which embeds learning in a holistic and realistic context that supports ill-structured problems. These two foundations (the psychological and pedagogical, respectively) are highly consistent with one another. Another suitable *pedagogical foundation* is an apprenticeship model (see 2.4.5.2) that provides scaffolding and coaching in knowledge, heuristics, and techniques in the context of authentic tasks. Context is vital for effective processing, negotiation, and application of information.

3. In constructivism, lesson content and heuristics are best integrated into the learning task and interpreted by learners, rather than taught by an external agent. Thus learners assume a high degree of control over their learning process. In this context, *technology* is not used as a tutor, but rather as a tool to explore and manipulate resources, and to integrate knowledge in the process of problem solving or meeting personal learning goals.

4. *Cultural considerations* play a role when academic communities tackle far-reaching issues - establishing standards and setting priorities - and in so doing, are influenced by their beliefs about learning, technology, or pedagogy. (In this context the term 'cultural' refers to the organisational culture of the learning community, as well as culture in the conventional sense.)

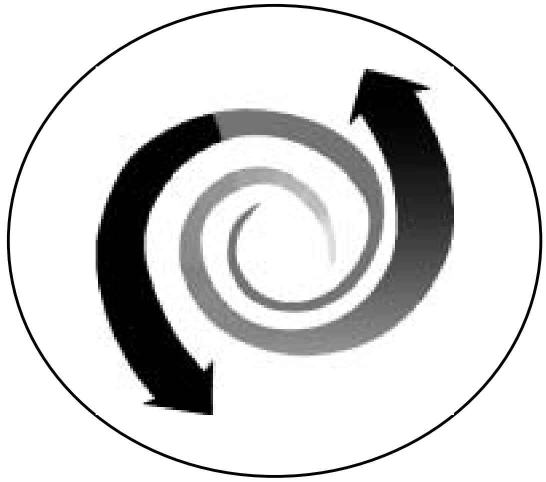
5. The tendency towards extreme constructivism can be mitigated when aiming *pragmatically* for a learning environment with an aligned, balanced foundation. Reasonable accommodations should be implemented, based on the unique features of each situation.

3.4.3.4 The revised R2D2 model

The original recursive, reflective design and development model (Willis, 1995) was introduced in section 3.4.3.1. The revised model (Willis and Wright, 2000) is based on Willis' (2000) subsequent guidelines for constructivist instructional design. The proposals embodied in R2D2, namely: recursion, reflection, and the added quality of participation, are illustrative and flexible, not rigid. Laying down strategies would be out of line with the spirit of constructivism, since constructivist principles (Willis, 1998) comprise more of a **framework and guidelines** for thinking about teaching and learning than a set of prescriptive principles.

R2D2 has been used to develop a wide range of educational materials - from videos to electronic books and web sites. The description in 3.4.3.1 of the first version used certain standard ID terminology with different meanings. This led to confusion, so the revised version more aptly uses terms from constructivist and related theories, as well as expanding the original model.

Figure 3.6 The revised R2D2 model
(Based on Willis and Wright, 2000:16)



The graphic representation in Figure 3.6 is quite different from Figure 3.4, as it shows interwoven focus areas spiraling out from the centre (which represents the first version) towards the end result which end-users may adapt and revise to suit their purposes. Willis' version of this model in an early stage of design (a separate figure which is not shown in this study (Willis and Wright 2000:6)), has an initial fuzzy focus. It becomes sharper as work progresses, and Figure 3.6 shows the end result, the product ready for end-users who may adapt and customize it for their unique needs.

The components (focus points)
These were defined in section 3.4.3.1 and only salient issues are mentioned here.

Definition focus (not a phase - more a view of the overall approach):

1. The beginning of the project is not characterized by the definition of objectives or by the analysis of learners and tasks - these emerge throughout the process. Instead, the expert designer's *first task is to create, support, and facilitate a participatory team,* sharing decision-making and exploration of issues with this team. It should comprise members from the different stakeholder groups - teachers, learners, graphic artists, designers, etc. Participatory design, or user-centred design, whereby the intended end-users play an important role in designing the system is a controversial issue - as non-professionals become full participants rather than objects of study.
2. R2D2 views the overall *process as one of progressively solving multiple problems* in context, rather than one subdivided into distinct stages. The initial 'fuzzy' objectives influence the design and development work, and these, in turn, refine the objectives. Design is an interactive process in which solutions emerge across a process. Work on different parts affects others and the whole.
3. *Contextual understanding*: R2D2 and other C-ID models emphasize the uniqueness of each design context. There cannot be a general ID method applicable across different settings

Design and development focus

These two activities have traditionally been separated, primarily due to technical factors. Design had to be finalised prior to development, because it was time-consuming and expensive to revise implementations during development. Current development environments, however, are powerful, flexible, and change-friendly, facilitating the combining of R2D2 design and development into a single, integrated activity. Experimentation and exploration of alternatives are stressed, also involving team members who are not computer programmers. Design relies heavily on tools - maintaining a balance between the three criteria of power, flexibility, and accessibility. Tools vary from a simple flipchart through computer graphics packages to video-editing and authoring environments. The actual development of materials tends to have some linearity as interface, components, and paths are combined in prototypes. Evaluation has evolved from the formative evaluation of the original R2D2 to *co-operative inquiry*. Co-operative inquiry (Heron, 1996, cited in Willis & Wright, 2000) is a process whereby two or more people research a topic by personal experience, in cycles, reflecting jointly on it. In R2D2, team members continuously research and reflect in a co-operative manner, with a view to improving the material. This is not done at defined points during development, but iteratively throughout. In line with constructivist practice, student assessment in tryouts of the materials is more qualitative (entailing interviews-in-context, observations, debriefing, portfolios, etc.) than quantitative (based on objective tests).

Dissemination focus

In the usual ID models, this comprises summative evaluation, final packaging, diffusion and adoption. Summative evaluation in the R2D2 model is not a demonstration that the product works effectively; rather, it is record of how the material is used in a particular context, in a particular way, with a particular group of learners. Traditional summative evaluation uses objective measures. Constructivist approaches may encourage individual goal setting by students and diverse learning activities, therefore objective tests would be inappropriate for evaluating the success of instruction, since different students learn different things in different ways.

The constructivist emphasis on the role of context suggests that the tasks of diffusion and adoption should not promote the 'right' use of material, but rather help users (both educators and learners) to adapt materials for the best possible use in their own context. Innovative, unanticipated, and creative uses of the material are to be welcomed and can be shared with other educators.

3.4.3.5 Activity theory as a framework for designing constructivist learning environments

Activity theory (Jonassen & Rohrer-Murphy, 1999), which originated from the classical German philosophy of Kant and Hegel, is a framework for studying various forms of human practice as developmental processes, interlinking individual and social levels. It can be applied as a framework to model a constructivist learning environment.

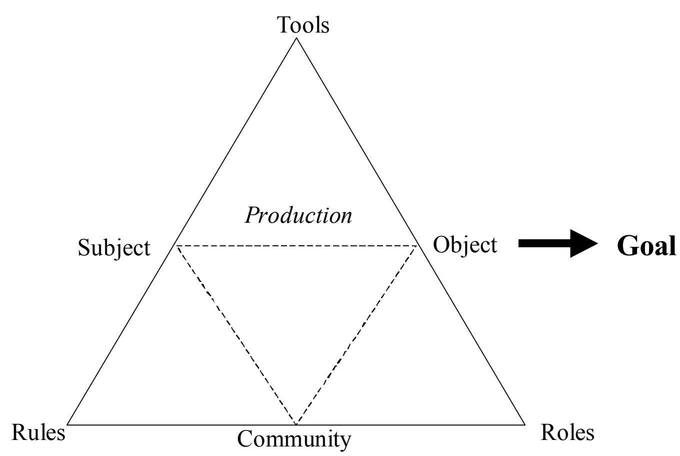
Activity theory

Activity theory postulates that learning and activity are interrelated - *conscious learning emerges from activity, rather than preceding it*. The implication for designing instruction is that the context of learning and performance is vital, since activity cannot be understood outside its context. Relevant aspects are: the kind of activity, who performs it, what results from it, its rules and norms, and the wider community within which it occurs.

Activity systems

The components of an activity are modeled on a triangle, shown in Figure 3.7.

Figure 3.7 Activity system
(Jonassen & Rohrer-Murphy, 1999:63)



The three prime components are the *subject* and the *object* of the activity and the *community* in which they occur. The subject is the individual/s engaged in the activity, and the object is that which results or is sought, i.e. the motivating intention of the activity. In ID, for example, the object may be a curriculum design.

The supporting components - the structural pivots on the apexes of the triangle - are the *tools* used in the transformation process, the *rules*, and the *roles*. In the ID example, the tools would be the models and methods used. For an effective activity, they must be specific to the nature and culture of the activity. Thus 'tools alter the activity and are, in turn, altered by the activity as they adapt to its specifics' (Jonassen & Rohrer-Murphy, 1999:63). The other facets of triangle are the rules of the activity and the way in which the division of labour is negotiated within the community. Since activities are contextually bound, an activity system can be described only in the context of the community in which it operates. The community negotiates the rules and roles which define the division of labour, such as the allocation of tasks when ID is done by a team. The overall activity consists of a goal-directed hierarchy, in which the major activity transforms into chains of conscious actions, which in turn collapse into more automatic operations as they become more familiar and are internalized.

Assumptions of activity theory

Certain assumptions underlie activity systems and activity theory. These are:

- *Minds in context* - the unity of consciousness and activity. Activity theory challenges the separation of mind and body, positing that learning and knowing occur inseparably in the context of doing.
- *Consciousness as the unifying factor* - activity theory conceptualizes consciousness in a different way from cognitive psychology. It is not considered to be a set of discrete performances, such as remembering, classifying, decision-making, etc.; rather, it is the phenomenon that unifies attention, intention, memory, reasoning, and speech (Vygotsky, 1978, cited in Jonassen & Rohrer-Murphy, 1999). Consciousness is based in the wider activity system, so the changes in the situation are internalized and reflected in a person's conscious activities.
- *Intentionality* - activity theory focuses on the purposeful actions that are realized through conscious intentions.
- *Object-orientedness* - The intention of an activity is aimed at an object. The subject is motivated to transform the object as the accomplishment of their goal.
- *Historical-cultural dimension* - activities evolve over time within a culture and can only be fully understood by analyzing the historical development which shaped their beliefs and values.
- *Tool mediation* - activity theory assumes that tools mediate the nature of human activity. Activity can be understood by comprehending the tools that shaped it and the tool can be understood in the context of the way it was used and the needs it served. Tools change the process and are changed by the process.
- *Collaboration* - meaningful activity is seldom accomplished individually, the ability to perform depends on groups of people.

Activity theory as a framework for designing CLEs

Jonassen & Rohrer-Murphy (1999) assert that an activity system can be applied as a framework to model a constructivist learning environment (CLE). CLEs are introduced in 2.4.5.3 and elaborated in 3.4.4.2. The environment should be ill-structured and complex, but relevant and meaningful to learners. There are six major design steps, each of which has substeps and leads to outcomes:

1. *Clarify the purpose of the activity system (i.e. the CLE)*
   - Understand the relevant context of the activities in the CLE.
   - Understand the subjects, their motives for performing the activity, interpretations, and contradictions inherent in the system.
   - Analysis techniques: formal and informal documentation, observation, interviews.

   Outcomes:
   - Information to guide the construction of the problem space;
   - Goals of the participants, which help to define the object of the challenge problem.

2. *Analyse the activity system*
   - Define the subject - the group of learners who drive the system; and determine their roles, beliefs, expected outcomes, rules and roles, struggles, goal-motives, and relationship of these to the system and to society, division of labour, and perceived rewards.
   - Define the relevant community/ies - their maturity, statement of rules, social interaction, conflicts, relationship to external communities, norms, and goals of external communities.
   - Define the object, i.e. the thing to be transformed and move the subject towards the goal - the outcome of the activity: a presentation, report, theory, or combination; evaluation criteria and who will evaluate; extent to which completing the object will fulfil intentions.

   Outcomes:
   - All aspects of the problem/project to be modeled:
     - how to represent the problem and its manipulation space, and
     - the kinds of cognitive tools learners will need;
   - The goal of the CLE, i.e. what characterises an appropriate problem solution.

3. *Analyse the activity structure*
   - Define the activity structure (the activity —› action —› operation hierarchy): all the activities, the individual and co-operative actions they comprise, and in turn, the chains of operations the actions comprise; how this work has transformed over time, the norms, rules and procedures; theoretical foundations; goal-motives of the activity; and contradictions from viewpoints of all subjects.
   - Decompose the activity into its component actions and operations - this will entail observation and analysis.

   Outcomes:
   - All activities, actions, and operations to solve the problem in the CLE;
   - The process should be done in different contexts and related cases.

4. *Analyse tools and mediators*
   - Define the tools - physical and cognitive tools, instruments, signs, and procedures to be used; and determine what models and theories will guide the activity.
   - Investigate the rules - formal/informal rules and assumptions that might guide the activities; and how they have evolved.
   - Analyse role mediation - How are roles traditionally assigned? How does it affect group assignment? Do these roles relate to non-academic experiences? What freedom is there for the roles to change within the group?

   *Outcome*s:
   - ➢ The models, methods, and protocols that constrain activity in the real-world problem manipulation space;
   - ➢ The information resources learners will need.

5. *Analyse the content*
   - Internal context - What beliefs, assumptions, models, and methods are commonly held by working groups? How do individuals communicate and what tools did they find useful?
   - External context - What social interactions surround the activity? Which activities are critical, i.e. will be measured/ assessed? How are tasks organised - do they emerge naturally? Do the implied rules-and-roles for each group member differ from those formally stated? What formal/informal laws/assumptions guide the activities? Must they be explicitly stated?

   Outcomes:
   - ➢ The problem context;
   - ➢ Community of actors, social relations, and division of labour;
   - ➢ The contextual elements of the related cases to be presented to learners;
   - ➢ Tools and mediators for the real-world process, and collaboration tools.

6. *Analyse activity system dynamics*
   - Determine the interelationships between system components - study the dynamics; how they change; the formality/informality of the relationships. Are there contradictions / inconsistencies between the needs of the population and the goals of the learning activities. How do individuals see their personal goals with relation to their successes in the CLE?
   - How formal are the relationships between learners? - What drives change, how lasting are the changes, and how are the relationships perceived in the wider learning community?
   - How have these relationships changed over time - compare with this population in the past.

   Outcomes:

   The designer now links/hyperlinks the following components of the CLE:
   - ➢ Different parts of the problem space to each other,
   - ➢ The problem manipulation space to work group members and to the cognitive tools needed to perform the task;
   - ➢ Members of work groups to the mediators they use; and
   - ➢ All members of the learning community who are working on that CLE.

Finally: System functionality should be tested to determine whether other resources are needed. A final check of the system should be run, after which user testing should occur.

3.4.4 Design of learning in perspectives related to constructivism

This section re-visits concepts introduced in Chapter Two, discussing their practical implementation as applications of the theory. First, certain learning methods are addressed, namely: situated cognition, anchored instruction, and cognitive apprenticeship. The next applications relate to constructivist learning environments (CLEs), open-ended learning environments (OELEs), and problem-based learning - environments within which an entire learning experience may occur. The transition from direct instruction to learning environments has major implications.

The key to adoption and growth of learning and instructional systems is the ability to apply generic design processes across a variety of teaching-learning domains (Hannafin, 1996), the success of conventional ISD being a case in point. Learning environments do not have generalizable design models along the lines of the generic ISD approaches that exist for direct instruction. The initial learning environments for non-directive learning existed as case-examples, and it was not clear how they were developed or if the development processes could be generally applied. By the mid-1990s, however, design technologies and guidelines were coming into being for various open-learning approaches, although there is 'no unifying approach sufficiently robust to accommodate both the similarities and differences across approaches' (Hannafin, 1996:4). This section considers characteristics of such environments, and guidelines for designing them.

3.4.4.1 Situated cognition, anchored instruction, and cognitive apprenticeship

Situated cognition can be viewed as a psychological perspective and anchored instruction as an approach (see 2.4.5.1). Both view cognition and the circumstances supporting learning as inextricable. The implications for design of instruction (Hannafin, 1992; Jonassen, Campbell, & Davidson, 1994) are that learning should **not be decontextualized by isolating elements** in order to teach them. Learning should occur **within authentic tasks** and activities situated in real-world settings. Decontextualized learning can produce knowledge that is inert, whereas the exercise of knowledge and skills in appropriate contexts should be more meaningful. Such environments can be enhanced by the inclusion of various media.

Cognitive apprenticeship (Lebow 1993; Jonassen, Campbell & Davidson, 1994), introduced in 2.4.5.2, sets out to assist learners by embedding the learning of knowledge and skills in a functional context where support and assistance are available. Situational learning exposes learners to varied contexts, thus improving transfer of skills to diverse settings. Scaffolding is provided to extend the development of learners within their own *zones of proximal development*. Learners become engaged when they use knowledge directly in problem-solving processes, but should be coached by the educator in self-questioning and other metacognitive skills.

3.4.4.2 Constructivist learning environments (CLEs)

Throughout this study, it is implicitly and explicitly conveyed that constructivist learning differs considerably from traditional instruction. Constructivism emphasizes **contextual learning**, while traditional instruction and teaching impart knowledge in a systematic, didactic manner. Constructivist learning can occur in so-called constructivist learning environments (CLEs), which focus on authentic contextualization and the role of the learner. CLEs, introduced in 2.4.5.3, aim to engage learners in experientially constructing knowledge as they solve a problem or tackle a project as the focus of the environment, surrounded by various interpretive and intellectual support systems. While many examples of such environments exist, little practical advice is available for the instructional designer on how to construct them, especially how to tackle the analysis phase of design and development. Since the epistemic foundations of constructivism are so different from traditional instruction, the classical methods of needs and task analysis are unsuitable, and an appropriate set of alternative methods is required for analyzing desired learning and designing CLEs.

A CLE is based on an appropriate problem, question, or project with support from intellectual systems or tools; the goal of the learner is to interpret and solve the problem or complete the project (Jonassen, 1999). A well-designed CLE meets Squires' (1999) notion of authenticity from both cognitive and contextual perspectives, as described in 2.4.5.3.

Components and characteristics of a constructivist learning environment

The essential components of a CLE (Jonassen, 1999) are illustrated in Figure 3.8. CLEs are an ideal means of implementing question-based, case-based, problem-based, or project-based learning (2.4.5.4 and 3.4.4.4), with the problem as the focus of the environment, surrounded by support systems such as related cases, informational resources, cognitive- and collaboration tools, and social support. Although certain objectivist methods may be included in a CLE, the basic difference between CLEs and objectivist learning is that the **problem drives the learning**, rather than merely serving as an example of concepts and principles. In other words:

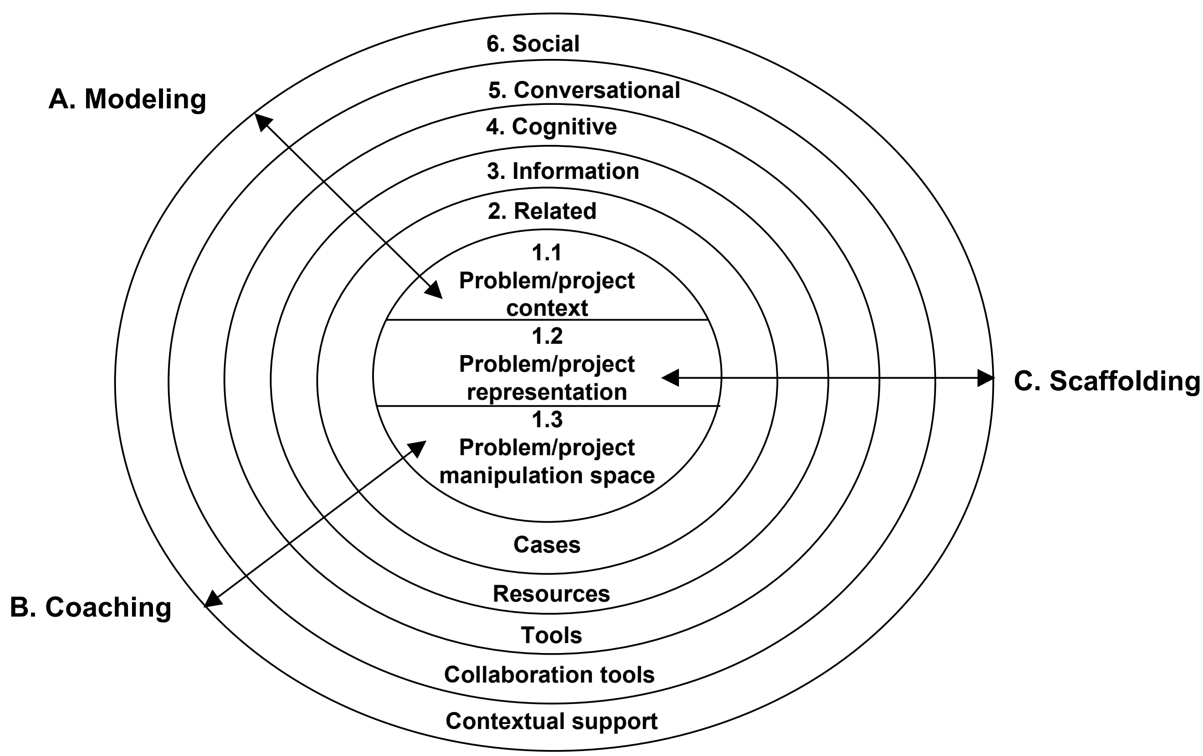
> *Students learn domain content in order to solve the problem, rather than solving the problem as an application of learning* (Jonassen 1999: 218).

The central issue or problem should be ill structured, so that some of its aspects would still emerge and be defined by the learners. Such ownership of the problem engenders the motivation to solve it.

Characteristics of ill-structured problems (Jonassen, 1999) are:

- Unstated goals and constraints;
- multiple solution paths or no solutions;
- multiple criteria for evaluating solutions;
- uncertainty regarding which concepts, rules, and principles to use, or even no general rules and principles for predicting the outcome; and
- learners are required to make and defend judgements.

Figure 3.8 Model for designing constructivist learning environments
(Jonassen 1999:218)



In a trans-concept study, Jonassen & Rohrer-Murphy (1999) apply the concepts and components of activity theory (see 3.4.3.5) as a possible framework for designing computer-based CLEs, depicted in Figure 3.8. The environment should consist of (Jonassen, 1999; Jonassen & Rohrer-Murphy, 1999):

1. *A problem-project space* - this presents a relevant, engaging problem or project, which is not well-structured and comes from a real-world context. The problem-project space comprises the:

1.1 Physical problem context which sets out the rules, community, and division of labour components of the activity system (see Figure 3.7 in 3.4.3.5), the stakeholders, and the appropriate climates;

1.2 Problem presentation/simulation describing the object of the activity system and replicating the tools, community and rules; and

1.3 Problem manipulation space in which learners act on the problem and see the results of their efforts.

2. *Related cases* - there should be access to related experiences in order to scaffold memory and represent complexity. This enables learners to relate prior experience to the current case, and addresses complexity by providing multiple perspectives.
3. *Information resources* - information banks, preferably multi-media, accessible via hyperlinks.
4. *Cognitive tools* - In addition to the tools of the domain, CLEs may incorporate cognitive tools as scaffolding to help learners perform those tasks. Examples are semantic organization, dynamic modeling, and knowledge-building tools.
5. *Conversation and collaborative tools* - CLEs frequently use computer-mediated communication to support collaboration among communities of learners. Information and knowledge-building tools are shared, and learners jointly construct knowledge tools. Means of communication are user-groups on the Internet, 'chats', computer conferencing, multi-user dungeons (MUDs), and object-oriented MUDs (MOOs).
6. *Social and contextual support* - Designers must accommodate environmental and contextual factors that affect implementation.

3.4.4.3 Open-ended learning environments (OELEs)

In the 1990s, interest grew in creating learning systems that differ from traditional direct instruction, by empowering individuals to learn, rather than promoting mastery of specific concepts (Hannafin *et al*, 1994; Hannafin, 1996). Open-ended learning environments (OELEs) introduced in 2.4.5.3, offer interactive learning within a technological environment. Like CLEs (see 3.4.4.2), they emphasize contextual learning and represent a shift from designer-managed to student-centric learning. However, they are not designed to teach particular content, to particular levels, for particular purposes, but to support learners' efforts to generate their own learning sequences. They are intended for situations where divergent thinking and multiple perspectives are preferable to single solutions, for example, the solving of ill-structured problems (Hannafin *et al*, 1999). OELEs are not restricted to a single paradigm, but there is a strong relationship with emerging psychological theories such as constructivism and situated cognition.

Underlying assumptions in open-ended learning

There are fundamental shifts in conceptualizations of the learner, knowledge, and the structure of the environment (Hannafin *et al*, 1994). Several critical assumptions and accompanying beliefs are:

1. *Context and experience are critical to understanding:*

   The process and the context of learning are inextricably tied. Knowledge detached from an authentic context is often inert knowledge which cannot be effectively employed or transferred across situations. OELEs aim to develop learning and problem solving from rich, concrete experience, embedded in an authentic context. The environment provides a type of phenomenarium where learners can manipulate parameters, alter the level of complexity, and create their own resulting products, for example, models, maps, experiments, etc. Activities in an OELE can both converge on and diverge from the topic to provide multiple perspectives.

2. *Understanding is individually mediated:*
   Customization of the OELE occurs as the self-directed learner takes active responsibility for the learning process. He/she determines what, when, and how learning will occur - asks relevant questions, extracts the required knowledge, evaluates and explains phenomena from personal experiences - true constructivism. The challenge for the instructional designer is how best to creatively support and guide these individualized processes without imposing injudicious external structures.

3. *Cultivating cognitive processes is often more important than generating learning products:*
   OELEs support higher-order cognitive skills such as manipulating variables, interpreting data, and hypothesizing. The idea is not to learn specific content and rules, but rather self-reflection. OELEs are appropriate in less structured contexts with domain-relevant thinking skills, and are not suitable for formal domains such as mathematics and science. The **inquiry process is valued more than acquisition of truths**, and problem solving is more important than procedural applications of formulae. Learners have to invoke cognitive and metacognitive skills as they, themselves, take the decisions, but in so doing, are guided by the system.

4. *Understanding is more vital than knowing*:
   A criticism of traditional instruction is the stress it places on recalling information. OELEs emphasize experiences that foster understanding through exploration, manipulation, and interaction. Learners have to determine the underlying reasons why a concept exists. The understanding gained is augmented by personal experiences, supported by cognitive scaffolding. Open-ended learning is philosophically consistent with the constructivist principle that reality is not definitive and objective, but a by-product of individual experience.

5. *Qualitatively different learning processes require qualitatively different methods:*
   Since OELEs focus on problem-solving skills and theory building in authentic contexts, it is necessary to provide the required tools, resources, and opportunities for multiple perspectives. The goals are qualitatively different from the outcomes of traditional instruction, and require completely different methods and activities in their support. Conceptually complex learning goals are difficult to achieve in conventional instruction, but OELEs aim to achieve complex and diverse learning goals by supplying appropriate tools and resources.

Characteristics of OELEs

Characteristics of OELEs are flexibly defined and span a broad spectrum (Hannafin *et al*, 1994). Their scope varies from microworlds, where relatively narrow but well-defined concepts are represented, to macro-level contexts where large sets of knowledge and skills are integrated. Microworlds such as Logo, popular in the 1980s, are an early example of pedagogical systems that are knowledge incubators, environments where learning is nurtured rather than knowledge taught (Papert, 1980). The content of OELEs varies from specific, isolated subject matter to material that is integrated cross-discipline.

Foundations and values of OELEs

OELE foundations and values (Hannafin, Land, & Oliver, 1999) indicate a confluence of several design features and strategies. In the context of grounded design (Section 3.1.2), Hannafin *et al* (1997) lay down five foundations of learning systems - foundations which should be balanced and aligned. These foundations were related to instructionism in 3.3.4.2 and constructivism in 3.4.3.3. Now OLEs are investigated in a similar way. With regard to their *psychological* foundations, a related combination is based on situated thinking, prior knowledge, experience, and metacognitive monitoring. Associated methods and *pedagogical* foundations are authentic learning contexts, anchored problems, scaffolding and construction. The *technological* foundations are based on various computer-based and Internet-based tools and resources, and their *culture* lies within the inquiry-oriented, critical thinking school.

User activities range from highly mathamagenic (i.e. using directed learner-responses and cognitive processes related to outcomes-based learning) through to generative processes where individuals use their own cognitive resources to identify, interpret, and elaborate concepts. Similarly, the *pedagogical* orientation spans a range from highly didactic to discovery-learning, depending on the orientation of the designer. OELEs are, however, more likely to incorporate generative and constructive strategies than mathemagenic activities, and learner-centredness rather than an external locus of control.

Finally ...

Hannafin (1996) acknowledges that **open-ended learning environments are not instruction**, and points out that **instruction is not the only, nor necessarily the best,** method to support learning.

3.4.4.4 Problem-based learning (PBL)

The concept of problem-based learning (PBL) is described in 2.4.5.4. It has the following practical implications for the design of instruction and learning environments (Savery & Duffy,1995):

Problem generation

The problem selected must make use of the content and principles relevant to the domain. The designer should initially identify the primary concepts that students must learn (often the same as the subject matter identified for traditional curricula), and generate problems that require the appropriate issues and principles in the course of their solution. Furthermore, the problems must be real, rather than realistic - for example, in medical education this entails genuine patients, and in secondary school environmental studies, learners could propose causes of, and solutions for relevant issues, such as local flood conditions. The reasons for using real problems are:

i. It can be difficult for the instructor to create rich problems;
ii. real problems engage the learners more; and
iii. learners want to know the eventual outcome of the actual situation.

Problem presentation

Students must take ownership of the problem if they are to engage in authentic problem solving - they must perceive its personal relevance. In presenting the situation, instructors should take care that the data presented does not emphasize the critical factors. Broad information must be provided, more than the key information required for the solution of typical end-of-chapter problems in textbooks.

Role of facilitator

Critical to the success of PBL is the ability of the tutor to teach as a facilitator rather than as an instructor. The facilitator's role is to ask questions that stimulate higher-order thinking skills and metacognition, and to challenge learners' thinking. Chien Sing (1999) points out that with a problem-solving approach, students are not instructed what to do or how to study. They should determine independently how to meet the learning goals and what resources to use, approaching problems from various perspectives and contexts. The facilitator guides and prompts them, and encourages them to test their hypotheses against the other learners.

The problem-driven approach is learner-centric and is highly effective in motivating learners. As they take ownership of a project/ problem, they gain advantages over and above conceptual understanding and the generation of a solution or a product. Learners more easily retain learning acquired by their own efforts and acquire new skills, such as decision-making, self confidence, negotiation, accessing resources, and technical expertise - that stand them in good stead throughout life. However, PBL does not lend itself to teaching basic knowledge, nor to acquisition of automaticity in subskills.

3.4.4.5 Implications of chaos theory for instructional design

Chaos theory, introduced in 2.4.5.7, postulates that all systems are subject to unexpected fluctuations and give rise to complex, unaccountable behaviour and random fluctuations. Instructional and learning systems are complex processes, similarly susceptible, and the implications of chaos theory for instructional design must be considered.

Paradoxes inherent in instructional design

Instructional systems design addresses an inherent contradiction. On the one hand, learners and the learning process tend to be unpredictable. On the other hand, the design of instruction and the systematic methods used in promoting learning are based on deterministic predictability, aiming to predict the learning outcomes of instructional interventions, implemented by reducing instructional events to simple, deterministic components.

Such 'putative determinism' (Jonassen, 1990:33) opposes the uncertainty put forward by chaos theory. Chaos theory, initially discussed in 2.4.5.7, challenges the relatively linear sequence of procedures within the traditional ISD model, proposing that the instructional process is too unpredictable to be relegated to a linear sequence of operations intended to produce reliable outcomes.

A second assault of the chaos perspective on ISD relates to the process of learning (Jonassen, 1990; Jonassen, Campbell, & Davidson, 1994). Cognitive models depict learning as an essentially linear process, moving information from short-term to long-tem memory. Individual learner differences however - effort, attitude, aptitude, and prior learning - impact chaotically upon learning events. Learning is a complex process, and complexity is an indicator of chaos. Despite this, learning does occur. The irony of chaos is that apparently random systems, such as learning systems, can manifest well-structured learning behaviours.

Laws and theories have been developed to describe learning and instructional processes. Experimental control is used in research on instructional systems (Jonassen, 1990), and frequently achieves results of *no significant difference* (Clark, 1994; Kozma, 1994; Russell, 1999). Chaos may well be a contributing factor to such outcomes, where order occurs spontaneously - chaos and order together. Chaos theory implies that it is not possible to tell how a given educational system or varying media will perform, thus questioning assumptions such as those of Clark and Kozma regarding the effects of media and methods.

How does chaos impact on ISD and technology?

Neither ISD theory nor practice can eliminate the effects of chaos. However, by using *qualitative evaluation techniques*, seeking appropriate measurement scales for learning, and interacting with - rather than intervening with - chaos, designers may be better able to understand and produce instructional systems. The learning process cannot be made completely predictable and controllable. Instructional systems should be dynamic and able to accommodate chaos by integrating factors such as learners' intentions, educational politics, social realities, etc. into their design and operation.

With this background, Jonassen, Campbell, and Davidson (1994) argue that instead of using multimedia to deliver instruction or even create environments for learning, multimedia technology **can be better used as environments or tools for learners to create their own products**. Theories and practices in harmony with this view on the role of media are cognitive apprenticeship (sections 2.4.5.2 and 3.4.4.1) and situated learning (see 2.4.5.1 and 3.4.4.1).

Chaos theory and instructional systems development

Chaos is a science of process rather than a state of existence. From this viewpoint, You (1993) applies chaos theory to set out an alternative approach to designing instruction. He compares and contrasts key concepts and assumptions of conventional instructional design with those of dynamic, nonlinear systems and chaos theory:

1. *Linearity versus nonlinearity*

   A linear system is based on the following assumptions:
   - Linear causality (cause-effect relationships are proportional),
     i.e. change in initial state results in proportional change in resulting state; and
   - The whole is the sum of its parts; a linear system is reductionist,
     i.e. understanding of the whole comes from decomposing it into component parts.

   Historically, reductionism has dominated ISD by activities such as needs analysis, performance analysis, task analysis, etc. The conventional ID model takes a linear path through these and other procedures aiming towards predetermined objectives by a predetermined sequence of steps.

   In contrast, nonlinear systems:
   - Assume mutual causality (cause-effect relationships are not proportional),
     i.e. a small change can result in a major effect; and
   - Holism: the whole is not the sum of the properties of its parts, especially in complex systems.

   Chaotic ISD models reflect the dynamic interrelationships which accommodate the integration of unanticipated events and unpredictable aspects of learning.

2. *Deterministic expected predictability versus indeterministic unpredictability*

   Instructional theories consist of principles that prescribe which instructional strategy to use for predetermined learning outcomes and conditions. It is assumed that the final outcomes can be predicted and that learning can be controlled by a reductionist approach, decomposing the system into various components. It is also assumed that changes in students' knowledge and skills can be predicted and implemented by defining behavioural learning objectives. On the other hand, chaos theory agues that it is impossible to control change, because small perturbations in initial conditions can have large, unexpected effects. Applying this to ISD denies the likelihood of predicting how students will respond to instructional intervention.

3. *Closed versus open systems*

   Traditional ISD has a closed-system view of learning, which cannot account for creativity or disequilibrium in human behaviour, and does not explore interactions of the instructional system with other systems in its environment. It is a limited, mechanistic model, which should be reconsidered from an open-system perspective.

   Under an open system, the process of developing instruction should have no beginning and no end, leading to a new, flexible design model that can be revised, can receive input from its environment, and can be easily adapted for contingencies. Its steps and components are interrelated and reciprocal; and the development process should not follow a linear path from analysis of the problem through to design and development of alternative instructional interventions, and finally to evaluation and revision. Thus ISD should be an open process, reflecting holistic adaptation, dynamic interaction between system components, and an interface to the environment.

4. *Negative feedback loop versus positive feedback loop*

   The purpose of a feedback loop in the traditional ISD process is to evaluate the model's own performance and the effectiveness of decisions with respect to the predetermined objectives. This is called a *negative feedback loop*, permitting corrective measures to be taken where necessary, in order to navigate the system away from deviations and towards a state of equilibrium. The traditional view is that behaviour which deviates from prespecified objectives is mistaken behaviour, and must be eliminated or modified in terms of the pre-set objectives.

   An open system, on the other hand, capitalizes on fluxes, perturbations, anomalies, and errors, which serve as triggers for reorganization. Thus errors and imbalance are positive driving forces towards re-equilibration. The role of *positive feedback* is not the maintenance of equilibrium and progress towards preset objectives, but to trigger internal transformation. New ISD models should incorporate positive or deviation-amplifying feedback to facilitate information exchange between the system and environment, to initiate appropriate system response, and thus to regulate and renew itself. Instructional systems should continue *becoming*, rather than simply *being*. Positive feedback entails questioning, exploration, and reflection at each level of the system.

3.5 Cross-paradigms issues

Section 2.5 introduced features that occur cross-paradigm within learning experiences. This section pursues the same issues, investigating practical ways of designing and presenting instruction and learning environments/events so as to optimize on matters such as collaborative work, learner-centricity, and motivation. Attention is also paid to Perkins' five facets of a learning environment, a further cross-paradigm concept. The section is concluded by briefly viewing the role of technology in the design and practice of instruction.

3.5.1 Collaborative learning and co-operative learning

The difference between collaborative and co-operative learning, which was explained in Section 2.5.1, is illustrated in this section by some practical applications.

Nelson (1999) describes characteristics and contexts of *collaborative problem solving* (CPS). It is not usually suitable for procedural tasks accomplished by a fixed series of steps, since it is frustrating for groups to struggle with a solution when a highly developed procedure already exists and can be effectively taught directly. CPS is appropriate for heuristic tasks comprising a complex system of knowledge and skills that can be combined in different ways to complete the task successfully. Both instructor and learners must be amenable to this learner-centred approach, which entails real-life role shifts and power relationships in a rich social context. Collaborative learning cultivates relationships as learners jointly take ownership of authentic tasks. This prepares them for the real world and can develop a desire for life-long learning. Learners must become self-directed and take responsibility for their own learning. The instructor's role is to act as a resource and tutor, as well as to formulate focus questions. Just-in-time instruction should be provided when appropriate, and evaluation is done for both group and individual grades. The learning environment must be conducive to experimentation and inquiry, and should encourage open exchange of ideas and information.

Various studies indicate that *co-operative work* impacts positively both on learners' achievements and attitudes. A fairly common educational practice is joint work undertaken by co-operative pairs in contact-teaching situations, for example, learners jointly tackling a computer-based lesson. In such cases the purpose is not to develop a product, but to enrich learning of a skill. Unlike collaborative work, it is suitable for procedural tasks. Brush (1997) describes how mathematics scholars, working two at a computer on an integrated learning system, achieved academic and affective gains - outperforming in test achievement and showing more positive attitudes than those who worked individually. The learners appreciated the opportunity of mutual help. Verbalizing and explaining a concept to another person reinforced personal understanding. Moreover, learners working in pairs were more engrossed and less easily distracted than the control group. Various other studies have also reported the positive impact of collaborative learning on attitudes, motivation, and enthusiasm towards mathematical subject matter (Good *et al*, 1990; Davidson & Kroll, 1991; and Slavin, 1995; all cited in Brush, 1997).

Singhanayok and Hooper (1998) investigated the effects of learning alone or in co-operative learning groups on the performances of high and low achievers using a computer-based biology tutorial. The students were grouped heterogeneously by prior achievement, since students who typically exhibit ineffective learning behaviour when working alone, might benefit from exposure to higher achievers. Both high and low achievers performed better academically in the co-operative treatment and showed more positive attitudes towards group work, reinforcing Johnson and Johnson's belief (1991) that partners encourage one another towards mastery of material. The students were also subjected to pre-tests, immediate post-tests, and delayed post-tests to investigate retention. The co-operative learners showed significantly higher post-test scores, as well as greater long-term retention.

3.5.2 Learner-centricity, customization, and learner-control

These interrelated concepts, introduced in Section 2.5.2, are re-visited to investigate practical applications and implications for the design of instructional systems and learning events.

Learner-centred systems (Hannafin, 1992) define the student as principal arbiter in making judgments as to how learning will occur. Learners not only select and sequence educational activities, but also identify, cultivate, and satisfy their individual learning needs, thus customizing the system to their requirements. Personalized learning systems presume that learners have adequate metacognitive skills to make effective judgments. The implications for design and presentation of instruction are that emphasis should be placed on supporting *student-initiated navigation* through learning material and environments, rather than providing a principal means of knowledge transfer. An organizing theme or context is provided for learning activities, and optional help and elaboration are available. Student-centred learning systems take many forms and are implemented by various approaches, incorporating minimal formal instruction. Resources should be available to help learners address their knowledge/skill needs and assess their own progress. Similarly, Kozma (2000) promotes the design of learning environments which acknowledge that learning outcomes are owned by learners, and permit them to arrange the context of their learning. Such designs support learners in choosing goals, constructing strategies, assessing their knowledge, and monitoring their own progress. Such a shift would also result in different learners taking varying directions and learning different things.

Customization of systems and learning to individual learners is therefore implemented in different ways across the spectrum of learning theories:

- system-controlled branching (in behaviourist and traditional instructional systems),
- user-control, whereby learners navigate their own path, or control their instructional components by selecting their own content and/or instructional strategies,
- artificial intelligence student models,
- personal goal-setting in learning environments, and
- exploration, using own particular skills, within open-ended learning (constructivist approach).

Each has its strengths and inadequacies. System controlled/program-controlled branching diagnoses learners' abilities/weaknesses and places them on paths of appropriate treatment, but offers them no opportunities to take initiative. At the other pole, constructivist- and open learning environments are not a universal panacea. Some learners do not demonstrate the ability to effectively mediate their own learning. In certain cases the learner's desire to explore and pursue his/her own interests may be satisfied, but fundamental knowledge and skills may not be obtained.

Referring back to Singhanayok and Hooper's (1998) study of co-operative learning among high and low achievers (Section 3.5.1), there was also an investigation into the affect of *locus of control*. Both the individual and co-operative learning groups were further sub-divided by program-control and learner-control of the computer-based biology tutorial. The program-controlled learners moved through the material at a pace dictated by the computer and tackled content presented by the computer, whereas the learner-controlled groups could determine their own progress through the material and choose their own learning activities. The learner-controlled co-operative learners showed greater determination - they spent more time interacting with the tutorial, selected more options, and checked their concept learning more frequently than the individuals who used the learner-controlled version.

3.5.3 Creativity and motivation in instructional methods and resources

The value of creativity and motivation in instruction and learning is outlined in Section 2.5.3. The literature suggests various means of motivating learners (Keller, 1983; Keller & Suzuki, 1988; Malone, 1981). This section adds to the discussion by highlighting some aspects for designers of instruction.

Cognitive psychology traditionally held the cognitive and affective domains to be separate, and their respective applications in learning and instructional theory were also presented separately. Recent studies about the two domains indicate them to be highly interrelated (Martin & Wager, 1998), as already addressed in 2.3.4.1 and 2.5.3.2. New theories and research detect connections between the emotional subsystem of the brain and the cognitive subsystem - the two act in parallel, but sometimes the one is more in control, and sometimes the other (Le Doux, 1996, cited in Wager, 1998). Human cognitive and affective systems cannot be separated, with implications for the planning and design of instruction, in that systems and programs which motivate learners are more likely to result in cognition. Nevertheless, learning is work - it calls for directed effort and time spent on learning-related tasks rather than activities that might, in the short term, be more satisfying. Designers should recognize the complexity of the *affective/cognitive connection*, and attempt to incorporate features within learning environments that promote the value of hard work and effort (Wager, 1998). The values and attitudes that students bring to the task of learning are vital. *Creativity* and innovation in instruction can help to foster intrinsic motivation for the acquisition of knowledge and skills.

One way of generating *creative instructional approaches* is to consider the instruction in its totality early in the design process (Reigeluth, 1999). This generates an overall ideal vision of the product - leading to creativity in the instructional materials, and also generating enthusiasm in the design team.

With respect to the kind of creativity mentioned in 2.5.3.1, that in turn, *engenders creativity* within learners, Landa (1998) suggests that some programs requiring creativity from learners merely confront them with creative problems. With the aim of teaching creative thinking, instructional methods and products should rather focus on the dynamics of mental operations.

In an IT Forum discussion of creativity and instructional design (Wilkinson, 1997), participants represented a wide spectrum of viewpoints on engaging learners for the purpose of motivation, participation and true learning. Some suggestions relevant to this study are:

- Openness to the imagination, style and flair of the advertising industry, which grasps abstract concepts and makes them relevant, i.e. making use of creative individuals on a design team;
- Awareness of the difference between developing applications for instruction and learning and those for relaxation and amusement; yet acknowledging that the two can learn from each other, with the content and target being major factors in determining the mode/metaphor of presentation;
- Valuing the instincts of good teachers who know 'what works';
- Empathizing with students, rather than over-reliance on the findings of surveys and statistics;
- Using true-life issues as themes in learning environments, and aiming to place out-of-context aspects within the context, so as not to interrupt learner's flow;
- Recognizing that the organized principles of instructional design do not diminish creativity, but provide systematic delivery for that creativity;
- Ensuring that good engagement and good education are mutually reinforcing, by using formal training in ID as the addition of tools to enhance, not detract from, one's initial creativity, i.e. art using science to achieve greater impact.

3.5.4 Five facets of a learning environment

Any learning environment, whether or not it makes use of technology, comprises some of the following five facets (Perkins, 1991a):

1. Information bank

An information bank is a resource that serves as a source of explicit information, the classic examples being textbook and teacher. Technology provides a wealth of further resources: videos, multimedia, online encyclopaedias, tools such as a thesaurus, the World Wide Web, etc.

2. Symbol pads

These are surfaces for the construction and manipulation of symbols: slate, notebook, laptop computer, etc. which support learners' short term memories as they learn and develop concepts.

3. Construction kits

Construction kits comprise a collection of parts to be assembled: lego blocks, experimental kits, even virtual parts such as commands in a programming language.

4. Phenomenaria

These are areas that present phenomena, making them accessible, for example, classroom terrariums, laboratory apparatus, simulations, and microworlds.

5. Task managers

These are elements that set and guide tasks to be done in the course of learning, the classic example being the teacher. Textbooks play a role by offering exercises with solutions, and learners are expected to undertake a certain amount of self-management. Information technology offers electronic support in the form of computer-assisted instruction (CAI), intelligent tutoring systems (ITSs), and currently web-based learning (WBL) programmes.

3.5.5 Technology

This discussion on the practical features of instructional design and instructional systems development would not be complete without a brief discussion on aspects of the role of technology and its interrelationship with the design and practice of instruction. Each of the major paradigms addressed in this study makes extensive use of technology - as tutor, as an environment, or as a tool - in the delivery of instruction or the implementation of learning environments. One of the criteria used for selecting characteristics and theories to be investigated in this study (sections 1.4.4 and 1.4.5) emphasizes that the theories and features should be platform-independent, i.e. not be restricted to a specific technology. The study recognizes the value of technology in current instruction and learning - technology being fundamental to many of the elements under discussion and, in many cases a contributing factor to their evolution.

In Section 2.5.2, in the discussion of learner-centricity, mention was made of the role of media and technology in supporting learners, rather than controlling them. Mehl and Sinclair (1993:13) underscore this point as they speculate:

> *'If learning ... implies the construction of knowledge, will it mean that in future students will learn less from the computer, but more with the computer?'*

This rhetorical question is all the more apt in the context of the current electronic learning environment of the Internet and World Wide Web.

Estes and Clark (1999) propose a definition of technology in the context of problem-solving:

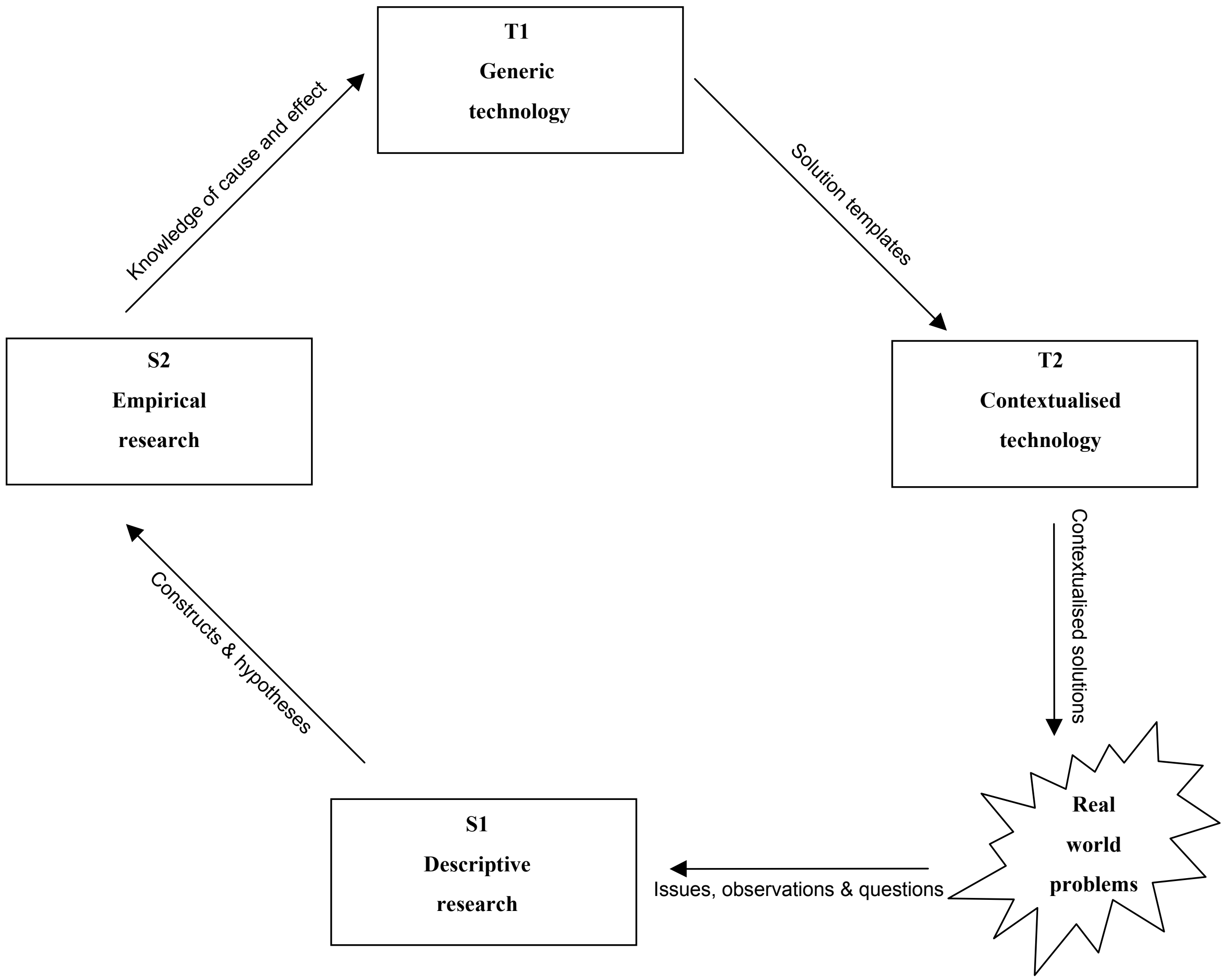
> *Technology is the application of scientific knowledge to human problems, and it includes a body of engineering methods and tools, related to, but distinct from, the tools and methods of science* (Estes & Clark, 1999:7).

The fundamental purpose of science is thus to generate new knowledge, while technology uses this knowledge to solve practical problems. Since much technology is shown to fail when subjected to scientifically rigorous testing, Estes and Clark offer a solution called *authentic educational technology*.

They perceive the authentic technology model as providing a useful framework, around which researchers and practitioners from differing theoretical perspectives can collaborate. The four-stage cycle of authentic educational technology, shown in Figure 3.9, is paradigm-independent and is based on translating knowledge into a technology for the purpose of solving real-world problems. Estes and Clark believe that practitioners from three schools of beliefs - the positivist/postpositivist, interpretive/constructivist, and critical theory/emancipatory (which focuses on social issues), would find common ground in the spiral model which is driven by real-world problems, focuses on effective solutions, and is vitally concerned with specific contexts.

Figure 3.9 indicates that the problem to be solved is the starting point, and must be clearly defined. Descriptive and empirical research should be identified that yield verified theory and interventions which are practically acceptable in the application environments. In the generic technology stage, the knowledge is translated into a technology, identifying an 'active ingredient' of the intervention which is the key to alleviation of the problem being solved. Finally, the generic technology is transformed into contextualized technology, packaging the active ingredient for delivery to the culture and context of the application setting. Qualitative and quantitative data are used at each stage of the model.

Figure 3.9 Development cycle of a science-based technology
(Estes & Clark, 1992:6)



Writing about the role of technology as far back as 1992, Bednar *et al* point out how IST draws principles of instructional design and development from empirical studies within a variety of paradigms and disciplines: behavioural learning theory, human information processing, cognitive theory, media design, adult learning, and systems theory. The greater the variety of technological tools, the more combinations of theory and practice emerge, in particular integrating the ideas of cognitive theory into professional practice in a field traditionally influenced by behavioural theory.

Whatever the applications of technology, they cannot be a panacea for inadequate foundations or a substitute for sound pedagogy. Kearsley (1998) expresses concern about the high profile of educational technology, arguing that the degree of attention it receives detracts from an emphasis on effective learning and sound teaching.

3.6 The learning-focused paradigm of instructional-design theory

The background to the so-called new paradigm of instructional theory and instructional-design theory, or learning-focused paradigm (Reigeluth, 1996a; 1997; Reigeluth & Squire, 1998) has been outlined in Section 2.6. The 'new paradigm' is not directly equivalent to any of the three major perspectives discussed in this chapter, but is an encompassing term for a diverse collection of contemporary theories and models. This section briefly overviews the ethos of the evolution, and shows the implications for instruction of the new approach.

3.6.1 Towards a new paradigm

Instructional-design theories and models at the outset of the 21st century

The emergence of the new learning-focused paradigm culminated in the publication of *Instructional-design theories and models: A new paradigm of instructional theory Volume II* (Reigeluth, 1999), as a follow-up to *Volume I* (Reigeluth, 1983). Fundamental changes in the systems served by ISD require associated fundamental changes, hence the appearance of *Volume II*. A most significant change is the use of the term 'design theory' instead of 'prescriptive theory', where design-oriented theories focus on means to attain given learning goals without the rigid connotations of prescription (Reigeluth, 1999). This section briefly overviews the content of *Volume II*, and investigates its implications for instructional and learning systems.

Volume II is distinguished from *Volume I* by the diversity of the models, in contrast to the commonality and relatively few kinds of learning covered in *Volume I* (Reigeluth & Squire, 1998). In order to meet current needs for human learning and development, instructional theories are incorporated which offer guidelines for:

- Fostering emotional, attitudinal, social, and ethical development in the *affective* domain; as well as those
- Geared towards deep understanding, cognitive tasks, higher-order thinking skills, and metacognitive strategies in the *cognitive* domain.

Among others, attention is paid to several of the theories and approaches addressed in this study - such as cognitive education, multiple approaches, constructivist learning, collaborative learning, and theories of Merrill. The idea is not that the new paradigm theories should replace the predominant paradigms; rather, they should incorporate certain established basic methods of instruction (for example, particular mention is made of Merrill's (1983) component display theory), but in the ethos of the newer guidelines.

The variety of theories allows practitioners to select those which best fit the needs of a given situation. Each fills a unique niche; many are complementary, and can be integrated or used to augment one another. A further feature of *Volume II* is that all the instructional theories are explicitly founded on *values* or underlying philosophies, which determine the type of goals the theory pursues and the instructional methods used to attain them (Reigeluth & Squire, 1998).

3.6.2 Reigeluth's classification according to instructional goal

Overviews of educational paradigms frequently categorize approaches and models on the *behaviourist* —> *cognitivist* —> *constructivist* spectrum (Figure 2.4), as is done in this study. Reigeluth and Squire (1998) describe a different classification in *Volume II,* according to the instructional goal of the theory. Occurrences of the three major paradigmatic-philosophies thus occur in more than one of their seven broad, but overlapping, categories:

1. Understanding

Understanding is essential if learners are to have the ability to transfer knowledge. The theories in this category emphasize deep understanding and the ability to apply information. Some are based on teaching rich, complex topics requiring authentic, performance-based assessment. Open learning environments are in this category since they present learners with resources, tools, and attributes to use in problem solving - either working with content or pursuing personal learning goals. Constructivist learning environments are also included, entailing the selection by learners of relevant information, its organization, and integration with existing knowledge.

2. Problem-based learning

The focus in these theories is active participation by learners in complex problem solving in ill-structured domains, often done collaboratively. Problem-based learning environments are an implementation of contructivist learning, and can also be termed case-based learning environments.

3. Community of learners

These theories refer specifically to collaborative learning, focusing on the socially-constructed nature of knowledge. Learning by means of group-work helps learners to attain strategies and management of their learning process, over and above the basic content skills.

4. Higher-order thinking skills

Many different theories aim to support learners in evaluating, self-monitoring, and developing thinking skills that transfer across domains. However, some theories are explicitly designed to develop critical and creative thinking skills in learners.

5. *Single categories*

This section covers one-of-a-kind instructional theories, including Merrill's instructional transaction theory, an extension of component display theory.

6. *Psychomotor domain*

Volume II also addresses domains to which little attention has been paid, namely, theories for training, coaching, and apprenticeships in physical skills such as art, sport, surgery, and trades. These skills are beyond the scope of the present study.

7. *Affective domain*

Recent research (see 3.5.3) indicates the importance of instruction in the affective domain, and its relevance to cognitive development. Certain theories exist primarily to foster personal, emotional, attitudinal, social, and spiritual development, character building, and life-skills.

3.6.3 Implications of the learning-focused paradigm

Pointing out how instruction's 'supersystems' are changing, Reigeluth (1996a; 1999) discusses **implications for instructional theory and practice**:

- Standardization should give way to customization, and the emphasis on 'sorting' students should be replaced by a focus on learning;
- Expectations of conformity, compliance, and passivity among students should be replaced by encouragement of diversity and initiative;
- The teacher should became a coach;
- Instruction should include construction - helping learners build their knowledge rather than just conveying it to them; and
- Learners need support as they acquire skills for complex cognitive tasks in ill-structured domains.

The kind of approaches outlined above would imply major changes for **the development of instructional systems** (Reigeluth, 1996a; 1999):

1. The ISD process should be less linear, more iterative and recursive. Traditional ISD is performed as a series of decisions, each preceded by its own type of analysis. This approach of completing analysis activities before design commences should be changed to just-in-time analysis. Furthermore, each decision should be evaluated as soon as possible, resulting in a series of analysis-synthesis-evaluation-change cycles;

2. ISD should be broadened to impact on its context, on the instructional system's super-system, i.e. at the level of the corporate structure or educational institution. Organizations have changed fundamentally in the Information Age, which in turn impacts on the way learners (employees and scholars) solve problems, work in teams, take initiative, and bring different perspectives to bear.
3. The process should be more active in facilitating the participation of all stakeholders. Not only does this ensure valuable input, but also leads to a sense of ownership over the resulting system.
4. ISD should incorporate a visioning activity after initial analysis, entailing all stakeholders reaching consensus on the general nature of the instruction - in terms of the ends and the means.
5. User-designers (facilitators and learners) should be involved in the design and creation of their own learning environments, tools, and materials, so that - while they are learning - learners may create or modify their instruction. A less radical approach is to provide systems in which learners make their own decisions about the content to tackle. In another scenario, the teacher can select/adapt/create material in novel ways during instructional activities. The framework of instruction could be pre-designed, but many decisions only be made during instruction.

   The actual value in practice of using learners on teams for designing and creating educational software is described by Steyn (2001), who involved students in developing a simulation for electrical concepts. Furthermore, in Section 2.6.4, which introduces Reigeluth's concept of user-designers, mention is made of Vincini's (2001) participatory design methods. In aiming for:
   (i) user-centred design,
   (ii) a shift from behaviourist and cognitivist ID towards a constructivist approach, and
   (iii) incorporation of Reeves' (1999, cited in Vincini, 2001) *learner-centred design principles of learnability, usability, and understandability,*

   Vincini incorporated the pilot-testing instructors and partnership instructional designers in the actual design and decision-making processes of producing a web-based electronic performance support system. She also involved representative learners at an early stage.

The approaches suggested in this section entail major changes – changes both in instructional theory/practice, and in the philosophy and methods of instructional design and development. Systems theory accepts the reality that there are different ways of accomplishing an end, but the new paradigm goes even further - in proposing that for different learners, there are **diverse ends** as well as **diverse means** of achieving them.

3.6.4 The debate on the learning-focused paradigm

Following Reigeluth's (1996a) initial call for a new paradigm, a dialogue resulted as Merrill (1996) responded, concerned about the influence of radical constructivism.

Merrill suggests that certain of Reigeluth's instructional strategies are not strategies but social learning environments, pointing out that conditions of learning are not determined by the setting. Agreeing that learners need skills to achieve complex cognitive tasks, Merrill argues that some of the existing instructional design paradigms (conceptualization/principle-using, etc.) address complex skills, obviating the need for a new paradigm. Regarding the proposal that the development process should be less linear, and more iterative and recursive, Merrill responds that, linear though the *models* might be, in *practice* real-world developers do integrate analysis and design.

Finally, he advocates learner-control of content and to some extent, of learning strategy, by presenting a choice of appropriate strategies, but disagrees with involving learners in the design of instruction - asserting that 'laziness' might prompt them to take the easiest path to a goal. Merrill also objects to 'visioning' with all stakeholders - an aspect beyond the scope of this study.

In response to Merrill's objections, Reigeluth (1996b) refers to two major kinds of instructional methods: *basic methods* - such as generalities, practice, and feedback, whose effectiveness has been scientifically demonstrated, and *alternative methods* - using a variety of media and methods for implementing the basic methods. He emphasizes that all theories accept the value of demonstrations, descriptions, and practice for the learning of a skill, but use varied terminology:

- Behaviourists refer to rules, examples, practice with feedback,
- cognitivists use terms such as cognitive apprenticeship and scaffolding, and
- constructivists 'walk the walk, though they refuse to talk the talk. Analysis of instruction designed by some radical constructivists reveals a plentiful use of these very instructional strategies' (Reigeluth 1996b:59).

Regarding *customization* and *learner-control*, Reigeluth argues that traditional instructional theories customize the learning process in a superficial manner. Alternative strategies, such as *team-based learning* and *problem-based learning* would be more effective. Finally, the traditional theories have not recognized that there are different ways to accomplish the same goal, nor that the methods selected depend on the values underlying the methods. In short, Reigeluth stands by his proposal for a new paradigm of instructional theory.

3.7 Duchastel's prolegomena to instructional-design theory: challenge for a full theory of instructional design

Before concluding this chapter on the development of instructional and learning systems, an independent proposal on the subject is summarized. This approach was followed in Chapter Two, where the author's study of instructional theories was reinforced in Section 2.7 by an overview of a separate, independent study. Similarly, in Chapter Three, the author's synthesis is supplemented with a report on a relevant viewpoint - this time, a discourse presented by Duchastel (1998).

Influenced by the pending publication of Reigeluth's (1999) collection of diverse theories of instructional design (Section 3.6), and with knowledge of its contents, Duchastel wrote a 'prolego-mena' to lay out the requirements for a *full theory of instructional design* (Shorter Oxford dictionary: *prolegemenon (*pl: *-mena)*: preliminary discourse, learned preamble; introductory observations).

Instead of an interactive network of theories, diverse in their situational specificity and underlying values, Duchastel calls for a single all-encompassing instructional design theory.
Such a single full theory (Duchastel, 1998) would show characteristics of:

- *Comprehensiveness* - covering all domains,
- *abstractness* - encompassing all processes,
- *utility* - wide applicability, and
- *validity* - grounded in psychology.

Duchastel defines a theory of instructional design as an organized set of prescriptions that assist in the preparation of instruction, i.e. a procedural model to be used by the instructional designer or instructor for preparing the actual execution of instruction. The theory would involve choices, choices rooted in beliefs about the underlying values of education. Duchastel does not propose such a theory, but sets the scene:

> *... for it to be proposed by the more creative theorists, young and older, that may be attracted to this challenge* (Duchastel 1998:1).

He draws a distinction between *instruction* and *instructional design*, a distinction that may be blurred in some of the current literature, but which emerges under several headings in Duchastel's paper.

3.7.1 Many current theories - resulting confusion

In Duchastel's (1998) opinion, the many diverse theories and frameworks in Reigeluth's anthology evoke unease - a situation 'where Babel reigns'. The forest should be sought from behind the trees, so as to progress towards theoretical integration.

Duchastel views instructional science as an artificial science, a prescriptive not a descriptive science (see 3.1.2), aiming to specify means towards satisfaction of a goal.

- The underlying scientific assumption is that, given a well-specified goal, there is arguably a best way to achieve it.
- The issue in instructional design, as in other design disciplines, is the pluralism factor - whether there is one best way to reach the goal, or in most cases, more than one method that can successfully attain it?
- Duchastel's answer is that, in theory, using a fine, detailed analysis, a specific method would be identified as optimal. But in practice, would it be worthwhile, or even possible, to conduct such an analytical study for the anticipated gains in effectiveness or efficiency. Realistically, more than one method may well be considered to be equivalent, i.e. pluralism is a pragmatic approach.

Duchastel, however, views pluralism as 'a mistake of grand proportion' (Duchastel, 1998:3). The crux of the problem is that each instructional design theorist typically develops his/her instructional-design theory according his/her selected educational philosophy, i.e. grounded in their own values - both regarding what should be taught and how it should be taught. There is general recognition of the diversity of theories, but in an 'islandship, whereby they remain largely isolated from one another, with little communication in terms of criticism and cross-pollination' (Duchastel, 1998:3). As an alternative to pluralism, Duchastel argues for the construction of a single *full theory of ID.*

3.7.2 Issues involved in building a full theory

Duchastel takes a strongly critical stance in meta-theoretical matters. Although aware that others would differ, he views pluralism as a problem that should be overcome. Three facets of the problem are identified: the *political* - related to curriculum aspects, i.e. what to teach; the *psychological* - the domain of learning theory; and the *sociological* - concerned with scientific community:

The political facet is the realm of curriculum theory – decisions regarding what is to be taught. The standard aims of education:

- Socializing the young,
- teaching them rational knowledge, and
- helping them realize their unique potential,

tend to be incompatible, undermining each other and resulting in divergent theories of instruction, and hence divergent approaches to instructional design. (Author's note: this is Duchastel's first reference to the difference between instruction and instructional design.)

Instructional designers should avoid involvement in curriculum theorizing and the aims of instruction. According to Duchastel, a mix of personal educational values and curriculum theory can lead to confusion, as illustrated by constructivist thinking.

Whatever the client's goal of instruction, Duchastel states that a designer of instruction should be able to take that goal and address it using a well-formed instructional design theory. The responsibilities of educational goal-setting and determining what is taught belong to the stakeholders in a given educational context. This is not the task of instructional designers - their role is to propose how best to teach what has been determined by others. Curriculum dialogue and negotiated decision-making may well occur, but they should not proselytize or engage in curriculum politics. When instructional designers avoid getting involved in issues of what to teach, it helps to position the science of ID beyond value-laden politics (Duchastel, 1998).

The psychological facet relates to learning theory, in particular the three current conceptions of educational psychology: associationist (behavioural), cognitive, and constructivist learning. These three are not integrated into a comprehensive theory that could deal with their relationships. Instead they are treated as alternative theories of learning, and are reflected by corresponding instructional-design theories. Each tends to have its own restricted domain of applicability and adds its own specificity to the learning process, extending the scope of instructional-design theory. Duchastel postulates that, **rather than wait for psychological learning theory to rationalize and consolidate, instructional-design theory should show the way**.

Duchastel addresses a few other issues relevant to learning theory. Although ID theorists should not be involved in educational content decisions, they cannot remain uncommitted with respect to learning theory, since their own inclinations and assumptions about learning play a major role. A further issue related to learning theory is the way in which knowledge is categorized. Bloom's taxonomy and Gagné's learning outcomes no longer play prime roles in knowledge analysis within ID, due to the emergence of constructivism and collaborative learning within contemporary educational thinking. Although **ID is a prescriptive science, learning theory is a descriptive science** - a natural science aimed at describing the natural processes involved in learning. In view of this, there is scope for potential unification in the discipline of learning theory, more so, in principle, than in instructional-design theory. Should such a consolidation in learning theory develop, it would facilitate a parallel consolidation within the fragmented instructional-design theories (Duchastel, 1998). In the absence of a consolidated theory, however, he believes that instructional-design theory should consolidate independently.

The sociological facet, concerned with the scientific community, relates to the lack of critical comparisons between the various theories. Duchastel believes that the major debate over constructivism which occurred in the first half of the 1990s, could have served a valuable purpose as a process model, if it had been more focused and less confrontational. However, the philosophical and biased nature of the discussion undermined the process and hindered true theoretical evolution. Possible reasons for this could be the situation of ID partially within the social sciences, and the socio-psychological aspects which constrained the needed dialogue. By contrast, claims should have been supported by scholarly arguments in order to positively impact the field. Increased cross-fertilization and constructive dialogue must occur in order to advance instructional-design theory.

What is instruction and what is instructional design?

What is involved in building a full theory of ID? First, what is instruction? It is essential to determine this as a prolegomenon to instructional-design theory (Duchastel, 1998).

At its most basic, instruction is an intentional effort to influence the thinking of persons. Learning occurs all the time on its own, but explicit instruction is goal-oriented, and is typically undertaken by an instructor/lecturer/teacher, directed at a target audience of learners/students, so as to organize their learning in a focused way. In the light of current practices of open learning, instruction can be defined as the 'crafting of information interactions for the benefit of the learner' (Duchastel 1998:8). So the goal of instruction is to organize learning, and the goal of instructional-design theory is to specify the design of instructional processes and products. (Note: a difference between instruction and instructional design.)

3.7.3 How instruction can influence learning

Three major aspects of influencing learning (Duchastel, 1998) are: *fostering motivation, structuring the learning situation*, and *how tightly controlled or open-ended instruction should be*. Consideration of each of these is affected by the theorist's values regarding what to teach, beliefs about learning, and views about instruction.

1. Motivation

Motivation relates to focusing learners' attention and maintaining engagement. Robert Gagné's instructional theory (see 3.2.3.1) placed motivation by gaining attention as the first event of instruction. Keller's theory (see 2.5.3.2) focuses principally on motivation. Currently, however, the means and source of motivation are closely related to content and to the situatedness of the instruction. Tendencies are towards approaches of authenticity such as just-in-time instruction, contextualised instruction - implemented in problem-based and case-based learning, and instruction within realistic settings or simulating reality. Such authentic instruction capitalizes on learners' natural curiosity and does away with artificial means of motivating students. When motivation is achieved inherently, then extrinsic motivation can be eliminated from instructional design. Motivation is an essential consideration in instructional design theory, but should explicitly be eliminated from instruction, since the content itself should motivate (a further distinction between instruction and instructional design).

2. S*tructuring the learning situation*

This aspect is also strongly related to content selection. Certain goals are best accomplished by strong sequencing and high control - for example, detailed concepts and operational procedures. Others require flexible, less rigid, instruction. The key decision is when to switch from a directive style of instruction to a more open, constructivist approach. The complexity of instructional situations and the variability within the environment make it difficult to lay down rules.

3. *Should instruction be tightly controlled or open-ended*?

There are major changes in current educational practice: from strongly directed to open learning; from teacher-centred to a learner-centric approach. These paradigm shifts relate to changing values and practices, associated with the transition from the industrial- to the information age. It goes beyond the different values of different educators, and is affected by the changing values of society. The content of education is moving from mundane elements of knowledge and compliant learner-attitudes, to higher forms of problem solving and initiative, for which open learning and constructivist environments (Hannafin, 1999; Jonassen, 1999) are more appealing. Thus the content of instruction has changed. What is required from the instructional design community, therefore, is a theoretical base and metarules that can handle both conventional instruction and the content approach to instructional interaction (another distinction between instruction and instructional design). Whether the form of learning is associative or a structural, the fundamental nature of the way learners interact with information in the environment does not change.

Instruction - process or product?

A final matter for the instructional design theorist is whether to view instruction as a process or a product. Classroom-teaching is a process, but it follows a plan and involves materials - a product view. Instruction via computer-based software is teaching by a *product*, but the product unfolds and manipulates an instructional event - thus becoming a *process*.

3.7.4 Towards a theory of instructional design

With this background, Duchastel (1998) derives principles for instructional design theorizing in order to provide structure for the prolegomena of a single instructional design theory:

1. *Determine the nature of learning and explicate it.*
   Set out one's own theory of learning explicitly.
2. *Characterize the interaction space leading to learning.*
   The interaction space is the intersection of the processes and products that engage the learner and shape the learning experience. Laying down a theory entails determining the components of this space and their interrelationships.
3. *Subjugate all content to the instructional function.*
   Instructional-design theory should not artificially motivate learners - the content should motivate.
4. *Keep out of curriculum decisions.*
   This is a societal decision, the territory of the educational stakeholders. Instructional designers must remain neutral, lest their theories become narrowly applicable.
5. *Attempt to devise rules of instruction.*
   Rules should be explicit, yet generally applicable. Forming rules is a heuristic exercise that can result in refinement of one's views, thus enhancing the theoretical base.
6. *Situate and confront.*
   Academic confrontation, comparative analyses, and positive criticism all form part of the sociology of theorizing and are integral parts of the process of scientific progress in all sciences of the artificial.

Despite his challenge and explication of aspects to be addressed within a full theory of instructional design, Duchastel is aware of the complex nature of setting out such a theory.

3.8 Instructional design approaches - eclectic and pure …

The discussion now moves on to overview various authors'opinions as to whether or not the approaches of the various paradigms to instructional design should be integrated. It serves not only as an apt pre-conclusion to this chapter, but also relates to the penultimate section of Chapter Two, namely Section 2.8, which investigates isolationism or integration between the philosophies.

3.8.1 Should aspects of different paradigms be combined in ISD?

Some advocate **no fusion**, suggesting that design can be effective only if it is closely coupled to a pure underlying theory. Bednar *et al* (1992), acknowledge that the field of instructional systems technology prides itself on eclecticism. A broad range of research on human learning is applied, and principles and techniques from various theoretical perspectives are placed within a practitioner's framework to achieve a particular learning goal or performance objective. Bednar *et al,* however, challenge this practice, arguing that abstracting concepts and strategies from their original theoretical framework strips them of their meaning by removing them from their underlying epistemological context. Developers should hold personal beliefs about the nature of learning, and explicitly apply concepts and strategies from theories consistent with those beliefs. Practical methods of instruction cannot be separated from a theoretical framework:

> *Instructional design and development must be based upon some theory of learning and/or cognition; effective design is possible only if the developer has developed reflexive awareness of the theoretical basis underlying the design* (Bednar *et al*, 1992:19).

In the context of the objectivism-constructivism controversy, Jonassen (1991b) queries specifically whether traditional instructional systems design and constructivism can be compatible, due to their fundamentally different approaches to learning theory. Similarly, Wills (1995) doubts that the broad differences between educational technologists on different sides can be bridged. In response to Dick's (1995) claim that constructivism has impacted positively on systematic ID procedures without undoing their intrinsic flavour, Willis (1995:9) refers to 'constructivist seasoning' added to 'behavioural ID stew', in that Dick's approach remains an empirical-rational one.

Others propose **accommodating alternative sets of values**. Merrill, Li, and Jones (1990a), Dick (1991), Lebow (1993), Reigeluth and Squire (1998), and Reigeluth (1989) argue from a pragmatic perspective that elements of objectivism, cognitivism, and constructivism can and should be combined in instructional models:

> *Since instructional theory needs to address all aspects of a practical problem, it must draw from all learning theories* (Reigeluth,1989:69).

There should not be an 'either/or debate' (Jonassen, 1994:37; Braden 1996). The best designers will select, apply, adapt, and extend attributes and components of various models and strategies to optimize instructional methods for the particular learning domain in hand. It is not obligatory to accept one specific viewpoint. Instructional design should draw eclectically on various psychological theories and, in conjunction with various learning and instructional theories, collectively determine appropriate directions. Dick (1991) and Winn (1992) refer to the need both for formal instruction based on traditional ISD paradigms, and situated learning within constructivist frameworks. Grounded design (Hannafin *et al*, 1997; Wilson, 1999) acknowledges the variety of sound, validated theories and correspondingly accepts a variety of instructional and learning practices, provided that they are rooted in some established theoretical framework, and their five foundations (Section 3.1.2) are consistent. This approach may be more realistic than a search for 'one true theory' (Wilson, 1999).

A further noteworthy viewpoint is that direct instruction and constructivism are not always mutually exclusive. *Learners can construct meaning from well-designed direct instruction* (Mayer, 1999:143). Mayer describes three views of learning, which correspond closely with the three paradigms of this study:

i. Response strengthening – association between stimulus and response;
ii. Knowledge acquisition – where learners place new information in long-term memory; and
iii. Knowledge construction – when learners actively construct knowledge representation in working memory. This is based mainly on the study of human learning in realistic settings, and views the learner as a sense-maker, the teacher as a cognitive guide who provides guidance on authentic academic tasks, and the instructional designer as the creator of environments in which learners interact meaningfully with academic material. In this context, Mayer promotes the design of instruction for constructivist learning.

Finally, Reigeluth distinguishes between eclecticism in the descriptive sciences and eclecticism in the prescriptive sciences. He suggests that while a descriptive scientist, such as a learning theorist, will adopt a single theory and work with it, a prescriptive researcher, such as an instructional theorist, should be pragmatic and open in addressing practical problems:

> *Eclecticism and multiple perspectives are strengths for practitioners - and even for theorists!* (Reigeluth, 1997:44).

In deciding which theory to use, practitioners should consider factors such as the kind of learning, the kind of learners, and constraints within the learning situation (Reigeluth & Squire, 1998).

3.8.2 Research methods to examine different paradigms

A strong research base exists for basic systematic instruction, which was traditionally investigated by empirical means. Much needs to be done on other forms, in particular the variable methods such as problem-based, project-based, and team learning, where experimental, quantitative research methods are not the most appropriate. Constructivist learning, with its creativity and flexibility, does not lend itself to research-based empiricism that links particular objectives to particular instructional strategies. Learning is too complex for such a reductionist approach. Thus 'a significant part of ID is rational rather than empirical' (Willis, 1998:9), requiring reflective consideration of all the complex factors confronting the designer. Moreover, certain findings under contrived research purposes are very different from occurrences in natural learning contexts (Hannafin, 1996). The advent of a 'completely knowable prescriptive instructional theory' (Winn, 1997:36) or a precise specification of guaranteed instructional methods is highly unlikely. Grounded theory is discussed by Hannafin *et al* (1997) and Willis (2000). This ongoing, iterative process of theory development permits the researcher freedom and **flexibility to investigate promising and unanticipated avenues** within a study, rather than treating new phenomena on a *post-hoc* basis or commencing a new study.

Where different paradigms are combined, therefore, differing research methodologies may be required to determine their effectiveness, varying from experimental methods through quantitative non-experimental means through to qualitative ethnographic research designs.

3.8.3 The practitioner in action

Effective learning is also a function of the practice of instruction. Actual instruction requires a climate of some flexibility. Schön (1987:15) uses the term 'professional artistry' to describe the competence of practitioners (in this context, educators) who adeptly handle situations of uncertainty and uniqueness. This kind of skillful performance is sometimes instinctive, and cannot be precisely articulated, a phenomenon Schön (1987:26) refers to as 'reflection-in-action'. It implicitly questions assumptions and gives rise to on-the-spot experimentation. Yet spontaneous reactions may indirectly shape future action as practitioners consider their reflection-in-action and use it towards subsequent structured actions.

The distinction between the design of instruction and the practice of instruction is mentioned by Wilson (1999) in the context of grounded design. Wilson values grounded design in relation to the development of models/tools to facilitate instruction and learning – asserting that instructional designers should be informed by theory and deliberately apply some theory of learning. In respect of real-life instruction, he would not require the same level of consistency between a given theory and practice, accepting that teachers may take a practitioner-centred approach, trying perspectives eclectically. People, rather than ideologies, are in control and the needs of the situation dictate the rules and values.

3.9 Conclusion

This chapter is an extensive overview of learning and instructional systems and their development models. In investigates practical applications of the learning theories discussed in Chapter Two, and makes explicit that which is often tacit, namely the distinction between learning theory, instructional design, and instructional practice.

Design of instruction and the different paradigms

Instructional design processes should be adapted or transformed so as to remain relevant on the cutting edge. Traditional ISD models are suitable for many forms of *basic, direct instruction* and practice, but do not lend themselves to the creation of constructivist learning materials, where passive learning of content is replaced by problem solving and learner-initiative. *Constructivism*, as a broad theoretical framework, does not naturally give rise to systematic design models, nor does it always require formal, tangible learning materials. Rather, it yields learning philosophies as a foundation for ID and associated principles/guidelines, although there are situations where C-ID processes exist for the development of constructivist resources (e.g. the R2D2- and layers-of-negotiation models, and grounded design). Reigeluth's *new paradigm of learning-focused instructional theory* (Section 3.6.3; Reigeluth, 1996a; 1996c; 1999; Reigeluth & Squire, 1998), which has commonalities with constructivism, also has implications for ISD such as non-linear development and the involvement of users as designers. ID should be situation-specific and embedded in context (Hwang, 1996) and thus requires a continuous process of re-invention so as to meet changing requirements.

Direct instruction is likely to play a less major role in the 21st century than it has in the 20th century, therefore a serious need exists to have sound philosophies and procedures for development of resources and tools for the alternatives - problem-based learning and learner-centred environments such as CLEs and OELEs.

Can varying theories be integrated in the design of learning and instruction?
Can they even co-exist?

The present researcher promotes compatibility, complementarity, and a position of considered compromise, provided that the **positions have a cognitive grounding**.

- Direct instruction of basic knowledge can be enhanced by selected tenets of constructivism;
- Balanced constructivism holds challenging promise and is strongly related to learner-centricity;
- Designers should integrate aspects of the available theories and strategies, so as to synergistically optimize on compatible and complementary stances.

In applying theory to practice, different theoretical perspectives are appropriate for supporting different kinds of learning. Within in a major learning experience, there are different forms of knowledge and skills to be acquired, processes which are supported by different frameworks and practices. Learners seldom attain the skills to competently tackle complex problems, without first grasping basic lower-level skills. Each theoretical perspective and its associated implementations offer practices and tools that facilitate

- different kinds of learning
- among different kinds of learners
- at varying stages and in different parts of instruction.

Learning theory, instructional theory, and instructional practice

This chapter addresses the relationship between descriptive learning theories and prescriptive instructional-design theories. The study has identified a further demarcation – the distinction between instructional design and instructional practice. In the context of traditional ISD, all three facets are separately evident: underlying learning theories, an instructional design process, and presentation of instruction. In the more contemporary approaches and learning environments, distinctions blur as facets merge. In particular, there is less emphasis on instructional development as a separate process, since design and delivery of instruction may converge. *Instructor-designers* are emerging and the focus is on the provision of environments for active learning, rather than on predefined learning systems.

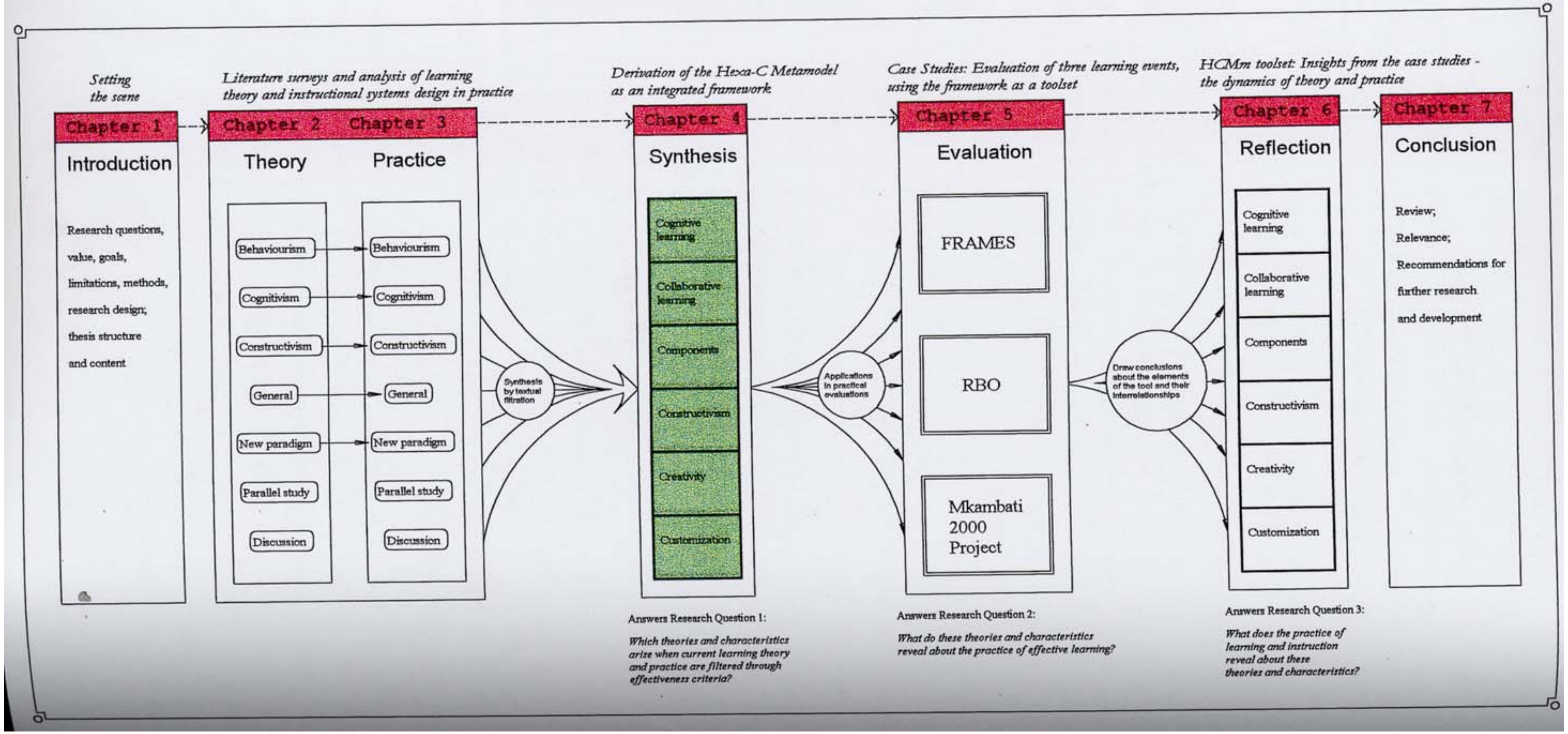
In conclusion …

Society in the early 21st century is characterized by social consciousness. The implication for education is that instruction and learning should not be addressed merely in a pragmatic manner but rooted in a value system. Educational practice has traditionally been founded on underlying values and philosophies, but implicitly so. The difference now is that values are made explicit and used by practitioners as the basis for decision-making.

Education, training and instruction are changing due to various factors. Technological advances open up new possibilities, and a democratic user-centric culture promotes the acquisition of life-skills along with content learning. Despite this, no learning theory or instructional approach can guarantee results, because the raw material of instruction is comprised of human learners with their varying backgrounds, values and biases, emotions, and abilities.

Chapter Four summarizes and analyses learning theories against certain criteria, and extracts a concise set of inter-related elements (theories and characteristics) which have utility for designing learning experiences, environments and events. The framework can also be used to evaluate existing learning events, and in a meta-manner, the more it reveals information about learning events, the more it reveals about its own elements. In other words, as **theory informs practice**, **so practice extends the theory.**

Structure of the thesis



Chapter Four

Synthesis

Towards a metamodel

4.1 Introduction

Chapter Two is a literature overview, which investigates various instructional and learning theories and stances, while Chapter Three similarly surveys practical aspects in the development of instructional systems and learning environments. Based on these studies, Chapter Four sets out to answer the first research question posed in Chapter One by investigating:

> *What theories and characteristics arise when current learning theory and practice are filtered through effectiveness criteria?*

The aim of the chapter is to use information from the literature to **develop a compact synthesis or framework of the current dynamics in learning and instructional design theories from the cognitive family, including characteristics of effective practice**, for the dual purpose of:

(i) Developing learning experiences and interactive learning environments, and

(ii) evaluating learning events and environments, from a learning theory perspective.

Practical implementation of the theories and characteristics that comprise the framework should both enhance the experience of the learner and support the task of the instructional designer / educator. However, not all elements of the framework would apply to every kind of learning experience. Second, the framework would also serve as an enquiry and evaluation tool, to be applied to existing learning experiences and events; educational materials and resources; and interactive learning environments, in order to investigate them from the viewpoint of contemporary learning theory.

Section 4.2 sets the scene for this chapter, with a parallel examination of the three main current theoretical stances and instructional paradigms discussed in Chapters Two and Three: behaviourism, cognitivism, and constructivism.

Section 4.3 re-introduces the selection criteria initially listed in Section 1.4.4. The researcher will use these effectiveness criteria to select and filter theories and characteristics, so as to extract key elements on which learning events and resources should be founded, i.e. theoretical foundations; and elements which should be incorporated within them, i.e. practical characteristics.

In Section 4.4, these nine selection criteria are applied to filter textual data, a process which leads to the derivation of a framework/synthesis, termed the Hexa-C Metamodel (HCMm).

Section 4.5 is a brief reversal of the process shown in Section 4.4. The six prime concepts emerging from the textual filtration are tabulated against the criteria to confirm their conformance.

Section 4.6 compares and contrasts aspects of the HCMm with Reigeluth's *new paradigm of ISD* and *learning-focused theory* (Reigeluth,1996a; 1996c; 1999; Reigeluth and Squire, 1998) and Duchastel's (1998) *prolegomena to a theory of instructional design*. With relation to Duchastel's challenge for a single, full theory of instructional design, the outcome of this study cannot be viewed as such. The proposed framework is not a single theory of instructional design, nor even a partial theory.

However, it does represent an attempt to identify a set of theoretical and practical features appropriate for effective learning and instructional environments and products, in line with the ethos of the so-called new paradigm.

4.2 Comparative analysis of the three major paradigms

This section summarises and discusses information extracted from the textual surveys of Chapters Two and Three, comparing and contrasting the three paradigms: behaviourism, cognitivism, and constructivism. As explained in Sections 1.2, 1.3, 1.6.2 and 4.1, it is a delimitation of this study to emphasize learning theories from the cognitive family. This comparative study, however, covers certain behaviourist aspects to set the context - in particular, the transition from behaviourism to cognitivism and the inclusion, under some circumstances, of objectivist methods within the latter approaches.

4.2.1 Comparison and contrast: a summary

The parallel examination of the three main current theoretical stances and instructional paradigms is carried out using four tables, which summarise the three approaches under different headers. Table 4.1 reflects the underlying philosophy of each approach, and Table 4.2 examines the impact of each on the ISD process, showing how the positions differ in producing instruction and in designing and developing instructional and learning resources, and in actual instruction. Tables 4.3 and 4.4 investigate the actual instructional and learning experience, as encountered under the three systems respectively - with Table 4.3 focusing on the learning process and Table 4.4 summarising the positions of the three stances on evaluation and assessment of learning.

The tables set out the purist positions, for example, behaviourism is presented in its original form rather than its later position, which was influenced by the strategies of the cognitive revolution and was characterised by more flexible ISD. In practice, there is a perceptual continuum - in every category, each of the three stances occupies an interval along the axis and overlaps with aspects of the others.

In setting out *the underlying philosophies*, Table 4.1 indicates how behaviourism aims for behavioural change, manifested by learners' responsive actions; whereas cognitivists stress cognitive response in the form of mental operations; and constructivism emphasizes the value of personal involvement in contextual and experiential learning.

Table 4.1 The paradigms: Their underlying philosophy

Characteristic of the paradigm	Behaviourism	Cognitivism	Constructivism
Operates on	Overt behaviour	Covert mental operations	Performance of authentic tasks
Implemented by	Instructional intervention	Interaction with internal and external environment	Self-regulation
Goal	Behavioural change; Performance	Reorganization of internal knowledge structures	Meaning interpreted from experience
Foundations of the theory and classic models	Skinner: Stimulus-response; Reinforcement-feedback	Newell and Simon: Human information processing	Schön: Reflection-in-action
	Gagné: Different conditions of learning for different learning outcomes	- Sensory perception (STM) - Cognitive reception (WM) - Encoding (LTM) - Retrieval	Lebouw: Intentional learning Values Bruner: - Theoretical framework - Own constructing
	Component display theory (CDT)		Problem-based learning (PBL)
Appropriate domain	Well-defined domains	Subject matter that explicitly incorporates higher-order thinking skills	Ill-defined, real-world situations
Recipients	Students	Learners	Learners
Affective locus	Extrinsic motivation	Fostered motivation (eg. ARCS model)	Intrinsic motivation
World view	Objective, universal reality - to be imparted to learner	Common understanding - to be attained by learner	Personal, subjective interpretation of reality; Social negotiation of meaning - collaborative environment

In examining the impact of each paradigm on the design of instructional systems, the analysis distinguishes between the processes and the products of ISD. Table 4.2 outlines characteristics of the *instructional design process*, and lists features of *ISD products*.

Table 4.2 Instructional and learning models: The ISD process

Characteristic	Behaviourism	Cognitivism	Constructivism
Objectives	Predefined learning objectives	Performance objectives; Integration of multiples objectives	Objectives & negotiated goals emerge across process - not same for each learner
Features of design and development process	Linear sequence of steps; Independent, discrete phases	Linear process, with feedback and revision; Iterated phases	Non-linear, recursive design and development; At times even chaotic
	Design of instruction separate from implementation	More integration; Some strategies selected during instruction	Roles of designers and actual educators converge
	Systematic labour-intensive development methodology	Creativity in design and development	Open system of design and development; Holistic and reflective
Features of ISD products	Reductionist: Component parts Decontextualised skills	Integrative: Parts-into-wholes; Transactions	Holistic: Construction, complexity, and contextual
	Identify objectives; Identify components of performances	Identify objectives; Identify procedures that enable performance	Identify case study Or problem
	Deterministic and replicable	Integrate affective and cognitive issues	Unpredictable and indeterministic
	Pre-planned learning experiences	Pre-planned options	Environments provided with resources and tools; Learners supported.
	Rigid models	Flexibility within the Given framework	Incorporated subversion
	Learning designed to achieve outcomes	Learning designed to result in mental processes	Designed to stress Learning gain
	Instructional strategies appropriate for the kind of learning	Cognitive strategies focusing on developing learners' knowledge structures	Principles, guidelines
Evaluation	Emphasis on summative evaluation	Emphasis on formative evaluation	Formative evaluation by learners and experts
Role players	Expert ID practitioners produce instruction	Professional designers	Participatory, negotiated design, including user-designers and teachers/trainers/instructors
Research approach	Proven strategies; Media comparisons; Empirical analysis; Research-based	Cognitive science Information processing theory	Qualitative, real-world effects; Subjective analysis

Table 4.2 sets the scene for Table 4.3, which describes the *learning processes* that occur using the various instructional/learning resources

Table 4.3 Actual instruction and learning: The learning process			
Characteristic	**Behaviourism**	**Cognitivism**	**Constructivism**
Pre-requisite	Defined entry behaviour	Prior knowledge in mental models	Zone of proximal development; Cognitive readiness
Perception of learners	Standardisation and conformity	Individualisation within standard tuition	Customisation; Supports diversity of learners
	Passive recipients	Interactive participants	Active constructors
	Instructor-centric; Instructor and instructional materials mediate knowledge	Instructor as facilitator and materials as activators of knowledge	Learner-centric; Tasks and problems that are personally relevant.
	Direct instruction	Supported cognitive processes	Anchored instruction; Apprenticeship
Nature of Learning process	Simplification of complexity	Integrate new with prior knowledge	Cognitive conflict, complexity, and incongruities
	Linear learning of components; Sequence of events	Non-linear integration And association	Contextualized learning activities; Problem-solving
	Teaching and practice segments interspersed	Guided practice	Real-life tasks; Scaffolding to support learning activities
	Events of instruction: Gain attention, explain objectives, stimulate prior knowledge, present stimuli, guide learning, elicit performance, feedback, assess performance, enhance retention and transfer.	Relate to prior learning; Support decision-making; Foster self-monitoring and metacognitive skills; Activate learning strategies; Enable transfer; Motivational (ARCS) Application of learning	Learning experiences: Holistic approach,; Collaborative learning; Rich learning environments and tools; Refinement and evolution of beliefs; Multiple perspectives Problem-driven learning
Expected learning outcomes	Observable, measurable behaviour and skills; What learners *do*	Internal cognitive activity; Mental models; What learners *know* and *how* they know it	Reflection; Learners-ownership of both process and problem
	Information transferred and knowledge instilled	Information assimilated and re-assembled	Knowledge constructed from personal experience
Approach to domain	Cover domain comprehensively	Grasp interrelationships; Classify, organise , decode	Information access, extraction, exploration and organisation
Learner-content relationship	Automaticity; Mastery	Deep understanding; Discovery	Just-in-time, as needed; Exploration
	Bottom-up	Integrated	Top-down
	Predetermined solutions to problems	Fixed problems and solutions	Open-ended activities
Ethos	Individual achievement; Competitive ratings	Individual achievement; Cognition	Social context; Cooperative; Collaborative
Role of computer / technology	Technology controls learning (tutor)	Towards learner control	Technology as tool; Augmenting learning
	Drill and practice; tutorials; Scoring and record-keeping	Tutorials incorporating scoring and record-keeping	Internet and other navigable resources; Multimedia

Tables 4.3 and 4.4 investigate actual instruction and learning under the three paradigms. With regard to the behavioural products/resources/learning events and the instructional/learning experience that occurs from their use, behaviourist instruction is basically predefined, but in learner-centric constructivist learning, no two presentations of the same course will be identical. Following on Table 4.3, which outlines characteristics of the different learning processes, Table 4.4 summarises *evaluation and assessment of learning* within the three stances, showing major differences.

Table 4.4 Actual instruction and learning: Evaluation of learning

Characteristic of the paradigm	**Behaviourism**	**Cognitivism**	**Constructivism**
Purpose of assessment	Assessment corresponds with objectives (may be drawn up before instruction is developed)	Assessment according to objectives	Goal-free / socially-constructed goals / personal goals
	Master sub-skills in prescribed sequence	Components and composite skills	Authentic tasks
Mechanism of assessment	Criterion-referenced assessment; Assessment instruments		Integrated assessment
	Correct solutions exist		Open-ended problems
	Bring learners to prescribed level	Elicit reasoning	Learning gain
	Formal testing; Frequently multiple choice	Formal testing	Multi-modality, i.e. portfolio assessment and project assessment
	Mark allocation (grading) by instructor		Peer evaluation; Self evaluation; Evaluation by facilitator
	Quantified measures		Qualitative measures; Context-dependent
View of errors	Negative reinforcement after error; Branching	Self-adjustment after error	Positive stimulants leading to Strategic exploration; Tentative beliefs challenged by errors

As indicated in the preceding tables, there are major variations between the paradigms with respect to the sequence and the tasks of the ISD process and equally powerful variations in the resulting products. Traditional instructional systems development within the behavioural, and to an extent, in the cognitive school, is a highly structured process. Constructivist design, on the other hand, cannot be limited to process design models, but is a more open and free process - sometimes aimed at developing specific resources, but often entailing the inter-relating of existing resources and defining learner-activities in the environment so created. Similarly, learning and instructional experiences are predetermined under behaviorism, relatively constrained under cognitivism, and much more flexible within constructivist situations.

What do these differences between the paradigms suggest in the context of this chapter? Rather than mutual exclusivity, this study proposes that **the differences suggest complementarity and different realms of applicability -** points which are explored further in Section 4.2.2.

4.2.2 The different approaches - conflict, convergence or co-existence?

Differing paradigms are currently being used within ID, leading to quite different answers to the same questions, with concomitant implications for the theorist, the designer, and the instructional practitioner. The differences are major, with origins deep in the core of the paradigms (Willis, 1998). Willis suggests that designers of instruction usually take one of three positions:

1. Decide which paradigm he/she accepts, and practice solely within its principles in a partisan fashion, making no attempt to design within two differing stances;
2. Separate core paradigm issues from instructional strategy issues. This entails partial reconciliation of conflicting paradigms, as a practitioner is a proponent of one ID position, but supports the use of certain strategies from another persuasion under certain circumstances; or
3. Place themselves within a particular paradigm, but accept that none of the current ID models have such firm foundations that they can be considered infallible. In other words, open democratic pragmatism is a basis for design and development that accommodates open-mindedness to methods and results from other paradigms, and even permits a change of paradigm.

The last approach is the one Willis recommends, and is the persuasion of the current author, who believes in an open approach, which integrates where appropriate and uses different methods and models in tandem where appropriate. This chapter, therefore **aims to develop a compact synthesis of current thinking in**

- **Learning theories from the cognitive family,**
- **instructional design theory, and**
- **characteristics of effective practice**.

The framework so generated should serve as a tool to facilitate development of effective instructional systems/resources and learning events/environments. It should also support meaningful inquiry into such, as well as further inform theory as it investigates the dynamics between learning theory and instructional design/practice.

Although there will not be explicit application of the behaviourist paradigm as such, the researcher believes that some of its aspects/methods hold value for incorporation within particular kinds of instruction and certain subject-matter domains, hence its inclusion in Tables 4.1 to 4.4.

4.3 Selection criteria

The extensive and intensive survey of learning theories and instructional systems development in Chapter Two and Chapter Three, summarized in Tables 4.1 - 4.4, identifies a daunting plurality of theories and models. The effectiveness criteria mentioned in Chapter One, Section 1.4.4, are re-visited and used to select appropriate theories and characteristics for learning events and environments. Positions and stances are sought which as a whole, comprise a concise set of theories from the cognitive family and characteristics that capture the essence and strengths of current learning theory and practice, i.e. positions and stances which:

1. *Are consensus-builders - methods applicable to situations that transcend paradigms*, i.e. a synergistic combination or integration of concepts that were initially used separately. Such integration works against exclusivity and is variously described as open democratic pragmatism or multiple frameworks (Reigeluth, 1996c; 1999; Greeno, Collins & Resnick, 1996; Hannafin *et al*, 1997; Willis, 1998; Duchastel, 1998).

2. *Demonstrate functionality and utility in authentic situations of training or instruction,* i.e. they should work in practice according to the values used to judge the methods, *even if they do not necessarily possess traditional empirical research-proven effectiveness* (Reigeluth 1989; 1999). Theories and characteristics are sought which promote the attainment by learners of both basic and problem-solving skills (Gagné, 1985; Jonassen, 1994; Hannafin, 1994). Conversely, much of what is 'proven' under controlled conditions contrived for research, works very differently in natural learning contexts (Hannafin, 1996). Willis (2000) advocates the grounded theory perspective, whereby a researcher begins a study without predefined hypotheses and methodologies. ‘In grounded theory what was wrong in traditional research is … acceptable, even desired and required’ (Willis, 2000:11).

3. *Are learning-focused for democratic societies where the learners' role is predominant,* in keeping with Reigeluth's (1996a, 1996c; 1997) 'new paradigm' and Jonassen's (1994) call for environments that support learner-learner collaboration with the educator serving as a coach or facilitator.

4. *Comply with pragmatic, rather than idealistic, purist considerations* - pragmatic considerations are one of the foundations of a learning system (Hannafin *et al,* 1997) and may entail some compromise between theoretically ideal situations, available resources, and constraints. The aim should be to achieve a balanced and aligned foundation for a learning experience. Jonassen (1999), a protagonist of constructivism, advocates the use of both constructivist and objectivist methods in appropriate contexts within constructivist learning environments, and makes the point that 'to impose a single belief or perspective is decidedly non-constructivist' (Jonassen 1999: 217).

5. *Conform to the general requirement that formal instruction incorporates some form of external assessment / marking / grading of learners*, i.e. more than mere learning gain or self-assessment should be measured (Braden, 1996; Dick & Carey, 1996).
6. *Integrate affective and cognitive aspects* (Tennyson & Nielsen, 1998; Martin & Wager, 1998; Duchastel, 1998).
7. *Incorporate means of communicating complexity* in ways that either simplify it (Merrill, 1991) in a decontextualized manner (where appropriate), or support it (Perkins, 1991b) when it is encountered in context.
8. *Are platform-independent for means of presenting instruction;* i.e. not tightly coupled to a single technology/medium for delivery (Clark, 1994; Kozma, 1994; Russell; 1999).
9. *Prepare learners to apply skills in practice and use knowledge in real life*, so as to facilitate application, retention, and transfer in the real world (Estes & Clark, 1992).

The first and most important criterion aims, within the context of current philosophy and practice, to select theories and characteristics that can transcend exclusivity and that, explicitly or implicitly, can be incorporated in appropriate ways into instructional environments and events to foster effective learning. The criteria, which derive deductively from theory and inductively from practice, by a process of filtration of textual data should be used as general guidelines and be applied within realistic constraints. It is not the intention that every position or characteristic selected should comply with all nine criteria.

Certain concepts occur across the board, in many contexts and in different kinds of learning events. Some features transcend underlying philosophies; others are integrally associated with a particular paradigm. The search is on to define underlying theories and characteristics of learning environments which support and facilitate learning. It is a cross-paradigm search for contextually and currently relevant stances and features.

In the next section these nine selection criteria are used to set up a textual filtration process. In this process, textual data comprising philosophies and practices relating to learning/instructional theories (Chapters Two and Three) are tested against the criteria. Theories and stances that comply are then extracted, processed, and used as a basis for generating the metamodel.

4.4 Selection process - culminating in the Hexa-C Metamodel

Section 4.4 demonstrates and explains how the metamodel was generated. The findings of the textual filtration process are recorded in three series of tables, accompanied by discussion.

4.4.1 How the selection criteria were used to filter textual data

The nine criteria of Section 4.3 were applied to the information in Chapters Two and Three, examining the concepts studied to identify aspects in these two chapters that satisfy the criteria. Elements and features were selected from **the theoretical, informational and principle-type material** in the two chapters, and not from information regarding specific ISD or C-ID models.

The theories, concepts, and characteristics which conform to Criterion 1 to Criterion 9 are listed in Tables 4.5.1 through to 4.5.9 respectively. The next set of tables, Tables 4.6.1 - 4.6.9, are concise summaries of Tables 4.5.1 - 4.5.9 respectively, with 4.6.1 corresponding to 4.5.1, etc. The 4.6 series represents reduced, consolidated versions - grouping together characteristics that are repeated or related, and scoring them to record the incidence of repeating characteristics and theories. The scores are used to derive a compact and concise set of theories and characteristics that capture the essence and strengths of effective learning theory and instructional practice as required in Section 4.3. Finally, Tables 4.7.1, 4.7.2, and 4.7.3 integrate, consolidate, and total all the information from Tables 4.6.1 - 4.6.9, grouping each occurrence of related stances and characteristics under a single label.

For example, Table 4.5.1 and Table 4.6.1 were derived as follows: The material in Chapters Two and Three was filtered through Criterion 1 to identify and extract concepts that satisfy it. Where the requirements of the criterion were met by a feature/property of a theory/characteristic reviewed, the concept was entered in Table 4.5.1. Concepts selected by this text filtration process are listed in Table 4.5.1, along with their sections of origin, and are subsequently consolidated and totalled in the associated summary table, Table 4.6.1. Some of the composite concepts give rise to more than one corresponding entry in Table 4.6.1. The subsequent pairs of tables are derived in the same manner, using the successive criteria. The derivation of the 4.7 series of tables is explained in Section 4.4.3

Section 4.4.2 contains Tables 4.5.1 - 4.5.9 and their corresponding summaries, Tables 4.6.1 - 4.6.9. Section 4.4.3 follows with a review of the criteria and the results of their application. This section includes a major table, which consolidates all the findings. In Section 4.4.4 the textual data filtration process and its results are discussed, and the concise set of related concepts, namely the Hexa-C metamodel is introduced. The metamodel is not a formal model in and of itself - rather, it is an integrated framework comprising overlapping stances and models, whose utility in analysis and meta-analysis is demonstrated in Chapters Five and Six.

4.4.2 Results of the textual filtration process

Table 4.5.1 shows textual data that emerged when concepts and methods were sought, and situations mentioned, that transcend paradigms and decry exclusivity.

Table 4.5.1 Criterion 1: *Consensus-builder*
(Methods/stances that transcend paradigms)

From Chapter Two:

- Behaviourist learning viewed as construction of a set of S-R associations (2.2.1).
- Humanist-cognitive viewpoint on human verbal behaviour (2.2.5) by which behaviourists and non-behaviourists agree on important role played by individual's cultural and social origins.
- Cognitive learning: Construction by learners of knowledge (2.3.2).
- CDT draws from various learning theories (2.3.3.3).
- Cases arise, even in constructivist learning, where learners need to acquire objectivist understanding from an expert (2.4.4).
- Many learning events incorporate aspects based on objective traditions as well as elements of constructivism (2.4.6).
- Learner-centredness transcends paradigm boundaries (2.5.2).
- Basic methods are used cross-paradigm (2.6.2).
- The new paradigm should incorporate much of the knowledge of previous models, but re-structured into the new context (2.8).
- Systematic ID, structured, direct instruction and objectivism have a place within all types of learning, with a transition to constructivist approaches at advanced stages (2.8).

From Chapter Three:

- Grounded design can be applied to any learning theory, as well as cross-platform, provided that it is consistently rooted on an underlying theoretical stance, and that it achieves alignment between its underlying principles (3.1.2).
- Instructionism straddles the divide between behaviourism and cognitivism – it uses direct instruction, but founded on cognitive psychology (3.3.4.2).
- Five-star instructional design rating has hybrid requirements (3.3.4.3).
- Customization is implemented in different ways across the spectrum of learning theories (3.5.2).
- Researchers from different theoretical perspectives can collaborate around the authentic educational technology model (3.5.5).
- All the instructional theories have means of implementing basic skills – but use varied terminology (3.6.4).
- Cross-fertilization must occur / A theoretical base and meta-rules are required that can handle both conventional instruction and the content approach (3.7).
- Learners can construct meaning from well-designed direct instruction (3.8).

Table 4.5.2 lists characteristics and approaches that satisfy the criterion which tests for functionality in authentic situations of teaching/learning, although they may not be explicitly research-proven.

Table 4.5.2 Criterion 2:

Demonstrates functionality in authentic situations of instruction/training

(Works in practice, even if not research-proven)

From Chapter Two:

- Observable behaviour/Stimulus-response-reinforcement (2.2.1).
- Practice on prerequisites and components helps learners boost performance (2.2.1).
- Objectives (2.2.2).
- Different conditions of learning for different learning outcomes (2.2.3.1).
- Cognitive learning: prior <--> new knowledge (2.3.2.1).
- Cognition: human information processing for problem-solving (2.3.3.1 and 2.3.3.2).
- Automaticity in subskills (2.3.3.6).
- Customization: learners determine own progress & learning activities (2.5.2)
- Kellers ARCS model enhances the learning experience (2.5.3.2).
- Traditional introductive theory is implemented by basic methods, which increase the problem of certain types of learning (2.6.2).
- Traditional ID process models relied on research and empirical data re different methods, but it is also possible to select what 'works best', depending on the values used to judge methods (2.6.5).
- Learning can occur from participation in the practices of communities and social practices (2.7.3).
- Instructional strategies should be selected from the context of theoretical frameworks, but they may originate from different families of instructional strategies (2.9).

From Chapter Three:

- Reinforcement and correction guide learners to achieve defined goals (3.2.1).
- Gagné's events of instruction (3.2.3.1).
- Cognitive learning: learning within problem-solving situations for the sake of correct performance (3.3.2.3).
- CDT: Each learner selects components he/she needs as an individual (3.3.3.1).
- Interaction between learners, and articulating knowledge to others consolidates learning (3.3.4.1).
- Instructional designers must support learners in individual knowledge construction (3.4.1).
- Multiple perspectives on the content (3.4.2.1).
- Encourage strategic exploration of errors (3.4.2.2).
- Social negotiation helps learners build mental models (3.4.2.3).
- Give learners ownership of the overall problem and of the problem-solving process (3.4.2.4).
- Constructivism, like reflective practice, is based on flexible guidelines rather than rules of inquiry (3.4.2.5).
- Client-centred designs: involve users at each stage of design of instruction (3.4.3.2).
- For ill-structured problems, embed learning in a holistic and realistic context (3.4.3.3).
- Users may creatively adapt learning materials for the best use in their own context (3.4.3.4).
- Cognitive apprenticeship: scaffolding and coaching extend the development of learners (3.4.4.1).
- Understanding is inextricably tied to the process and context of learning (3.4.4.3).
- Understanding is individually mediated (3.4.4.3).
- Cultivating cognitive processes can be more important than learning truths and solving problems (3.4.4.3).
- Students must take ownership of a problem in order to solve it, i.e. it must be personally relevant (3.4.4.4).
- Errors and behaviour that deviate from stated objectives must be used as forces for re-equilibrium (3.4.4.5).
- Students who learned cooperatively scored higher (3.5.1).
- Learners in learner-centred systems must have metacognitive skills to make effective judgements (3.5.2).
- Good education/ using what 'works' engages learners (3.5.3)
- Teachers select/adapt/create materials in novel ways <u>during</u> instruction (3.6.3).
- Constructivist learning, with its creativity/flexibility does not lend itself to research-based empiricism (3.8).

In Table 4.5.3 concepts are shown that contribute towards democratic, learning-focused instruction.

Table 4.5.3 Criterion 3: ***Learning-focused*** (Learners' interests are predominant)
From Chapter Two: • Student models and tutoring modules to support individual learners (2.3.1.1). • Cognitivism learning: Mental schemata (2.3.2.1). • Component display theory: different types of knowledge / different types of performance (2.3.3.3). • Cognitive networks : interaction of content & cognitive strategies for problem-solving (2.3.4.1). • Metacognition (2.3.4.3). • Cognitivism: Students viewed as true learners / independent thinkers (2.3.5). • Constructivism: Personal experience and relevance / collaborative learning (2.4.1). • Learning differs from learner to learner (2.4.1). • Learning is socially negotiated (2.4.1) (2.4.2). • Constructivism-collaborative learning connection (2.4.3). • Constructivism: more about facilitating learning than about pre-prepared instruction (2.4.3). • Constructivism: learner as prominent as facilitator (2.4.3). • Constructivism: learner in control – individuals make decisions and develop their own knowledge (2.4.5.3). • Collaborative learning: groups of learners working together, sharing responsibility, interacting and empowering learners (2.5.1). • Customization is the most important distinction between instruction in the Information Age and that in the Industrial Age (2.5.2). • Creativity engages learners and holds their attention (2.5.3.1); meets their needs (2.5.3.1). • Creativity in instructional strategies must enhance learning, not reduce its status (2.5.3.2). • Learning-focused approach entails: - individual learners taking control/responsibility, - working in teams and doing peer-teaching, - using technology as tools (2.6.3). • S-R associations entail connectionist learning, whereby information instilled strengthens certain connections (2.7.1). • Cognitive learning means constructing patterns of symbols and relationships to understand concepts (2.7.2). • Constructivism: concerned about boring, out of context learning (2.8). • Constructivism and cognitivism avoid producing inert knowledge (2.8).
From Chapter Three: • Behaviorist perception principles lead to practical learning principles (3.2.2.1). • Gagne's events of instruction (3.2.3.1). • Cognitive ISD: learners have a role in mediating learning with instructor as activator of learning (3.3.1). • Individuality of each learner (3.3.1). • Constructivism is concerned with each learner's unique perspective (3.4.1.2). • Instructional goals negotiated, not imposed (3.4.2.1). • Less concerned with instructional strategies and more with supporting learner-control of their own activities (3.4.2.1). • Learning in context (3.4.2.1). • Support construction of knowledge by learners (3.4.2.3). • Challenge learners' thinking; learners should become critical thinkers and self-regulators (3.4.2.4). • Test personal ideas against alternative views of other learners (3.4.2.4). • Involve learners in participatory design of learning systems (3.4.2.5). • Provide for social negotiation as part of designing learning materials (3.4.3.2). (continued ...)

- Learning emerges from activity: define internal and external contexts of a learning activity and its system dynamics such as how individuals communicate, rules/roles for each individual, relationships and dynamics of all these aspects (3.4.3.5).
- Situated cognition: learning should not be decontextualized by isolating elements (3.4.4.1).
- Learners must also be coached in metacognitive skills (3.4.4.1).
- Open-ended learning environments are student-centric, using the capabilities of technology (3.4.4.3).
- Tutor should become more of a facilitator than an instructor (3.4.4.4).
- Learner-control of instructional components customizes learning (3.5.2).
- A learning-focused paradigm should be characterized by customization, expectations of diverse learners, the teacher becoming a coach, and learners building their knowledge with support and acquiring skills (3.6.3).

Table 4.5.4 indicates the results of textual filtration through a pragmatism-seeking criterion.

Table 4.5.4 Criterion 4: *Pragmatic, not theoretically idealistic*

(A balanced approach)

From Chapter Two:

- Instructionism: need-to-know basis reconciles theoretically-ideal with available resources/content (2.2.4.2).
- Cognitive psychology, *how* as well as *what* learners learn (2.3 and 2.3.1).
- Cognitive learning: Construction of knowledge (2.3.2.1).
- Teach certain higher-level skills outside of relevant problem i.e. skills can be generalizable (2.4.4).
- Cognitive flexibility theory: Approaches which are cognitive, based on constructivist assumptions, yet with an objectivist grounding (2.4.5).
- Some constructivist learning environments combine objectivism and constructivist methods as complemenatry design tools (2.4.5.3).
- Exclusivity of focus should be avoided; it leads to limited scopes and restricted practices (2.8).
- Different approaches to support different stages of learning.
- Hybrid approach combining:
  - Objectivist approach for basic practice,
  - Constructivism for complex domains and ill-structured aspects (2.8).

From Chapter Three:

- For a learning option to be effective, it must be founded on (i) psychological (ii) pedagogical (iii) technological (iv) cultural and (v) pragmatic considerations, with these five foundations being aligned so as to maximize coincidence (3.3.4.2 and 3.4.3.3).
- No single theory is the panacea for all instructional problems, yet all are designed to make learning a more realistic and meaningful process. (3.4.1).
- Traditional design principles can be applied towards self-directed changes within learners (3.4.2.2).
- Behaviourism and constructivism are not incompatible, in that different methods can be used for different kinds of problems (3.4.2.5:1).
- Within an activity system, define the activity structure, its operations and its component actions (3.4.3.5).
- Qualitatively different learning processes require qualitatively different methods. User activities in an OELE range from highly mathemagenic to generative processes where learners identify, interpret and elaborate concepts (3.4.4.3).
- Mitigate against extreme tendencies by aiming pragmatically for learning environments with aligned, balanced foundations (3.4.4.3).
- Current instructional design theories and models are characterised by diversity (3.6.1).
- Some learning goals are accomplished by high control, others by flexible instruction. The issue is when to switch from a directive style (tractable problems) to constructivist style (ill-defined problems) (3.7).

Table 4.5.5 and Table 4.5.6 show the results of filtering the material in Chapters Two and Three through criteria that test respectively for the incorporation of external assessment and the integration of affective and cognitive aspects.

Table 4.5.5 Criterion 5: *Incorporates some form of external assessment* (Grading)
From Chapter Two: • Objectives (2.2.2). • Testing objective beliefs (2.2.4.1). • Constructivism: multi-modality i.e. portfolio assessment (2.4.2.2: 1). • Constructivism: assessment of group work (2.4.2.1) / assessment of collaborative efforts (2.4.2.2: 2).
From Chapter Three: • Content, methods, and assessment designed to promote competence in defined outcomes (3.2.3.2 & 3.2.3.3). • Typical instruction a range of sequences, & activities & assessment arranged around educational goals (3.2.1). • Gagne's events of instruction include assessing performance (3.2.3.1). • Criterion-referenced tests (3.2.3.3). • Mastery learning (3.2.4). • Learners should evaluate one another's performance & provide mutual feedback (3.3.4.1). • Constructivist evaluation: problem-solving in a domain / learners required to reflect on learning (3.4.1.2). • Constructivism: flexible evaluation to accommodate variety in learners (3.4.2.1). • Constructivism: assessment of portfolios (3.3.3.6 and 3.4.2.7). • Constructivism: assessment of projects (3.3.3.6 and 3.4.2.7). • Objective tests are inappropriate, since different students learn in different ways (3.4.3.4).

Table 4.5.6 Criterion 6: *Integrates affective and cognitive aspects*
From Chapter Two: • Cognitivism: active participation and critical thinking by learners within cognitive processes (2.3.2). • Complexity theory: affective elements support critical thinking/decision-making/creativity in learners (2.3.4.1) • Constructivists believe individuals are intrinsically motivated to seek information (2.4.1). • Creative instruction motivates learners (2.5.3.2) • Dual coding (2.5.3.2). • Positive reinforcement motivates learners to respond correctly (2.7.1).
From Chapter Three: • Avoid external control of learning situations (3.4.2.1). • To make instruction personally relevant, emphasize affective domain of learning (3.4.2.2). • Learning process cannot be separated from learners' attitudes, values, and interests (3.4.2.2). • Embed reasons for learning into the activity (3.4.2.2). • For learning to occur, learners must be dissatisfied with their existing knowledge (3.4.3.2 - theoretical part). • Learners should become engaged when using knowledge in problem-solving (3.4.4.1). • Ownership of the problem engenders motivation in learners (3.4.4.2). • Problem-based learning: learner-centric and highly effective in engaging and motivating learners (3.4.4.4). • Collaborative learning: impacts positively on attitudes and motivation (3.5.1). • Affective and cognitive domains are closely related (3.5.3). • The 'new paradigm': incorporates theories and models that foster attitudinal & social development (affective domain) as well as those geared towards understanding and strategies in the cognitive domain (3.6.1). • Authentic instruction: content motivates learners inherently (3.7).

In Table 4.5.7 theories and concepts are shown that emerge from textual filtration through a criterion that seeks aspects which aim to communicate domain complexity. Table 4.5.8 indicates the result of filtration through the criterion of platform-independence.

Table 4.5.7 Criterion 7: *Has means to communicate domain complexity*
From Chapter Two: • Objective reality specified and instilled in learners (2.2.4.1). • Bottom-up, basics-first, modular instructionism (2.2.4.2). • Reductionism: Study / simplify components independently (2.2.4.3). • Enterprise schemas: multiple integrated objectives : facts & concepts in context (2.3.2.3). • Component display theory : components of learning (2.3.3.3). • Cognitive learning simplifies complexity (2.3.4.4). • Constructivism: Cognitive complexity handled by conflict deferred (2.4.3). • Situated cognition: presents complex, ill-structured situations (2.4.5.1).
From Chapter Three: • CDT: different content dimensions (3.3.3.1). • Incorporate cognitive and metacognitive strategies in instruction but without distracting from task-essential learning (3.3.4.1). • Stress connections within and beyond the information, integration of old & new, and relationships (3.3.4.1). • Constructivism : Design the learning environment to reflect the complexity of the post-learning environment – rather than simplifying, support learner in situation of complexity (3.4.2.4). • Address complexity by providing multiple perspectives (3.4.4.2). • In an open-ended learning environment, it should be possible to alter the level of complexity (3.4.4.3). • Chaos theory: Learning is a complex process, but despite the complexity, learning does occur – even within random systems (3.4.4.5).

Table 4.5.8 Criterion 8: *Platform-independent* (Not restricted to a specific technology for presentation/performance of instruction)
From Chapter Two: • Component display theory (2.3.3.3). • Incorporated technology subversion: learners use environments in a way not originally intended (2.4.5.3). • Technology's role is to augment learning (2.4.5.3). • Media debates distract from the main purpose of media, which is to support individual learners (2.5.2). • Technology can be used in a flexible way to motivate learners (2.5.3.1). • Technology can support 'flow' (2.5.3.1). • Basic methods are implemented by means of variable methods of delivery (2.6.2).
From Chapter Three: • Predictive theory of ID – developing new rules during instruction (3.3.2.3). • Use technology as a tool (3.4.3.3). • Due to chaotic influences, a result often obtained in between-media experiments is 'no significant difference' (3.4.4.5). • Multi-media can better be used as environments or tools for learners to create their own products (3.4.4.5). • Learning environments (whether or not they use technology) comprise Perkins' five facets (3.5.4)

The results of the final textual filtration process - using Criterion Nine to find theories and stances that help learners apply knowledge and skills in the real world – are given in Table 4.5.9.

Table 4.5.9 Criterion 9: ***Helps learners apply knowledge and skills in practice*** (Real-world value)
From Chapter Two: • Transfer (2.3.4.2). • Constructivism: exposure to the real environment (2.4.2.1). • Constructivism: authentic tasks (2.4.2.1). • Constructivism: context-driven (2.4.2.1). • Anchored instruction – within realistic problem-solving environments (2.4.5.1). • Cognitive apprenticeship – instructor acts as a guide (2.4.5.2). • Problem-based learning & project based learning (2.4.5.4). • Chaos theory: real world phenomena are unpredictable, but there's order within chaos (2.4.5.7). • Learner centredness is accomplished best in problem-based approaches (2.5.2). • A well chosen theme is, of itself, a creative motivating force (2.5.3.2).
From Chapter Three: • Facts are not isolated, but are knowledge to be applied in real life (3.4.1.2). • Anchor learning activities to an authentic task or case-based problem (3.4.2.3). • Constructivism : Design the learning environment to reflect the complexity of the post-learning environment and support the learner in such situations of complexity (3.4.2.3). • Through social integration learners make sense of the world and find new ideas (3.4.3.2 - theoretical part). • For ill-structured problems, embed learning in a holistic and realistic context (3.4.3.3). • Activity theory: Conscious learning occurs when doing an activity, rather than preceding the activity; therefore the context of learning and performance is vital (3.4.3.5). • The problems presented should be real rather than realistic (3.4.4.4). • Learner-centred CPS entails real-life role shifts and power relationships in a rich social context (3.5.1). • Team-based learning and problem-based learning - using real problems - are learner-centric (3.6.2).

The purpose of the 4.5 series of tables is to show theories and characteristics that were extracted when the textual filtration process was applied to Chapters Two and Three to identify stances that conform to the nine selection criteria. As explained at the beginning of Section 4.4.1, the next series of tables, Tables 4.6.1 - 4.6.9, have a one-one relationship with Tables 4.5.1 - 4.5.9, in that they summarize them - with Table 4.6.1 corresponding to Table 4.5.1, etc. The 4.6 series shows summaries and scores of the results obtained from applying the nine criteria. They represent condensed, consolidated versions of the 4.5 series - grouping together concepts that are repeated or related, totalling them to record the incidence of repeating characteristics and theories, then listing them in decreasing sequence. The findings indicate which concepts and perspectives appear most frequently as a result of filtration through the effectiveness criteria.

Table 4.6.1 Summary and scores of results from Criterion 1:
Consensus-builder
(Can be used in situations that transcend paradigms)

Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Cross-paradigm / cross-platform / cross-theory	2	5	7
Combinations: Constructivism within objectivism / constructivism in direct instruction / cognitivism in behaviourism / constructivism in cognitivism	4	1	5
CDT / components / basic skills	3	1	4
Learner-centric systems / customization within different paradigms	1	1	2

Tables 4.5.1 and 4.6.1 show the results of textual filtration in seeking positions that *build consensus by transcending paradigms*. When applied to the literature of Chapters Two and Three, Criterion 1 extracted a total of twelve references to cross-platform applications and paradigm combinations.

Table 4.6.2 Summary and scores of results from Criterion 2:
Demonstrates functionality in authentic instructional/ training situations
(Works in practice)

Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Cognitive learning / apprenticeship / mental models / human information processing / metacognition	3	4	7
Motivation / creativity / novel ways	2	4	6
Constructivism: knowledge construction / multiple perspectives / exploration of errors		5	5
Customization / learner-centric / learner-ownership / client-centered / individually-mediated	1	4	5
Collaborative learning / shared responsibility / social negotiation	2	3	5
Objectives / outcomes / S-R / observable behaviour / Events of instruction	3	2	5
Basic methods / CDT /skills components / subskills	3	1	4
Context of learning		2	2
Cross-paradigm strategies	1		1

Criterion 2 (Tables 4.5.2 and 4.6.2) relates to aspects *that show functionality and foster learning in practical situations of instruction*. The highest score (seven) went to learning approaches that emphasize the role of the mind in comprehension and cognitive processing. This was followed closely by customized learning and collaborative learning (five mentions), with an equal count for objectivist traditions, demonstrating that in appropriate contexts and domains, aspects of behaviourism can, and do, foster learning. Component instruction and constructivism, far removed from one another, as well as engagement and creative aspects, each had a score of four mentions.

Table 4.6.3 Summary and scores of results from Criterion 3: *Learning-focused*
(Learners' interests predominant)

Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Learner-control / customisation / learner-centric / individuality of learners / negotiated goals	7	5	12
Collaborative learning / social negotiation / community of learners / participatory design	4	6	10
Cognitive learning / self-regulators / HIP / metacognition / critical thinkers / activators	5	4	9
Constructivism: active learning / facilitate learning / knowledge construction / technology as tool	4	3	7
Engage learners / creative strategies	3	1	4
Connectionist / Gagné / behaviourist principles	1	2	3
Contextual learning		3	3
Components	1	1	2

Using Reigeluths term, '*learning-focused'*, Criterion 3 (Tables 4.5.3 and 4.6.3) - seeking predominance of learners' interests - extracted its highest mention (twelve occurrences) from literature on matters such as learner-control, customization, individualization, etc, with collaborative / participatory aspects close behind at ten occurrences. Cognitive and constructivist aspects scored nine and seven respectively.

Table 4.6.4 Summary and scores of results from Criterion 4: *Pragmatic, not theoretically idealistic* (A balanced approach)			
Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Cross-paradigm / cross-theory / hybrid approach / different methods for different times or diverse problems / avoid exclusive focus	5	7	12
Instructionism / need-to-know / pragmatic ISD	2		2
Cognitive psychology / cognitive learning /	1	1	2
Decontextualized skills / component actions	1	1	2
Customizing learning in varied ways		1	1
Team approach		1	1
Knowledge construction	1		1

Tables 4.5.4 and 4.6.4 indicate that, over and above the references to cross-paradigm applications revealed by Criterion 1, Criterion 4 - relating to a *balanced, rather than theoretically ideal approach* - extracted a further twelve references to the value of a cross-theory, hybrid approach, using different methods at different times and avoiding exclusivity.

Table 4.6.5 Summary and scores of results from Criterion 5: *Incorporates some form of external assessment* (Grading)			
Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Constructivism: portfolio assessment / projects / journal / reflection /objective tests unsuitable	2	6	8
Objectives / outcomes / goals as basis for testing / events of instruction	2	3	5
Assess collaborative efforts	2	1	3
Criterion-referenced / mastery		2	2
Peer evaluation		1	1

Criterion 5 (Tables 4.5.5 and 4.6.5) acknowledges the requirement that *formal instruction incorporates learner-assessment*. The greatest number of references to conventional assessment/testing (five) was found in material on objectives and goals, but the overall highest score (eight) went to the newer constructivist-style assessment.

Table 4.6.6 Summary and scores of results from Criterion 6: *Integrates affective and cognitive aspects*			
Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Intrinsic motivation / creativity as motivator / personal relevance / foster emotional aspects / affective-cognitive link / ownership motivates / content motivates	3	9	12
Cognitive processes / active participation / ID for deep understanding / cognitive strategies / complexity theory	2	1	3
Learner-control / learner-centric		2	2
Constructivism: problem-based learning motivates		2	2
Collaborative learning		1	1
Extrinsic motivation	1		1

Filtration through the criterion, *Integration of cognitive and affective aspects* (Criterion 6 - Tables 4.5.6 and 4.6.6) extracted twelve mentions under aspects such as intrinsic motivation, creativity, and relevance; as well as three and two respectively under cognitive strategies/complexity theory and constructivist problem-solving.

Table 4.6.7 Summary and scores of results from Criterion 7: *Communicates domain complexity*			
Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Constructivism: support in managing complexity / cognitive complexity / situated cognition / scaffolding / alternative levels of complexity chaos theory	3	4	7
Components / basics first / CDT	3	1	4
Cognitive learning simplifies / cognitive and metacognitive strategies / integrate information	2	2	4
Objectives / specify objective reality	1		1
Concepts in context	1		1

Criterion 7 (Tables 4.5.7 and 4.6.7) stresses the need to *communicate complexity to learners,* either by working with inherent complexity or by simplifying it prior to transfer to learners. Seven references on management of intrinsic complexity were extracted from the various aspects of constructivism, and a total of eight emerged from sections on the use of cognitive methods (four) and component-based strategies (four).

Table 4.6.8 Summary and scores of results from Criterion 8: *Platform-independent* (Not restricted to a single or specific technology)			
Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Technology: as a tool / to enhance / to support	4	3	7
CDT / components / basic skills	2		2
Constructivism: technological subversion / flexible process of instruction	1	1	2
Innovative use of technology motivates learners	1		1
Different media - no significant difference		1	1

Theories and characteristics to be integrated into the proposed framework *should not be limited to a specific technology as means of delivery* (Criterion 8). Tables 4.5.8 and 4.6.8 stress the integral role of technology as a tool for current learning, and distribute various scores across the spectrum of the literature. It would appear that restriction to tightly-coupled forms of technology is not a valid threat.

Table 4.6.9 Summary and scores of results from Criterion 9:
Helps learners apply knowledge and skills in practice
(Real-world value)

Theory or characteristic	Number of occurrences		
	Chapter Two	Chapter Three	Total
Constructivism: authentic tasks / order within chaos / complexity / multiple perspectives / activity theory: learning-by-doing / anchored instruction /	4	4	8
Realistic context	2	1	3
PBL / realistic problem-solving / ill-structured	2		2
Cognitivism: transfer / instructor as guide	2		2
Learner-centered PBL / customization by problem-based learning	1	1	2
Team-approach / social negotiation		2	2
PBL motivates and engages learners	1		1
Components / facts		1	1

Criterion 9 (Tables 4.5.9 and 4.6.9) states that learning theories and characteristics should be sought that *help learners to apply knowledge and skills in the real world*. Constructivism (scoring eight) is undoubtedly the major force for supporting learners in real-world performance.

4.4.3 Consolidated results of the textual filtration process

Tables 4.7.1 and 4.7.2 integrate, consolidate, and total information from Tables 4.6.1 - 4.6.9, grouping each occurrence of related concepts under a single appropriate label. The scores are then used to derive a compact and concise set of theories and characteristics that capture the essence and strengths of learning- and instructional design theory/practice, as was required at the beginning of Section 4.3. Table 4.7.1 lists aspects that can be classified as instructional paradigms, philosophies of learning, or characteristics of instructional systems / learning environments – all part of or related to the cognitive family. Table 4.7.2 sets out other notable issues that emerged strongly from the textual filtration, yet which cannot be categorized as particular theories/characteristics of learning events. The findings in the tables are discussed in Section 4.4.4. Section 4.4.4 also includes Table 4.7.3, which presents concepts from the behavioural family that emerged from the textual filtration.

Table 4.7.1 Consolidated occurrences of learning theories and characteristics (from cognitive family)										
Theory or characteristic	**Criterion and its associated table in the 4.6 series**									
	1 **4.6.1**	**2** **4.6.2**	**3** **4.6.3**	**4** **4.6.4**	**5** **4.6.5**	**6** **4.6.6**	**7** **4.6.7**	**8** **4.6.8**	**9** **4.6.9**	**Total**
Knowledge construction, active learning, problem/project-based, authenticity, support in complexity, chaos theory, flexible instruction, anchored, ill-structured domains **(Constructivism)**		5	7	1	8	2	7	2	10	**42**
Cognition, cognitive learning, mental models, HIP, metacognition, self-regulation, integration **(Cognitivism)**		7	9	2		3	4		2	**27**
Affective aspects, intrinsic motivation, engage learners, creative/innovative strategies, affective-cognitive, ownership **(Creativity)**		6	4			12		1	1	**24**
Learner-centricity, learner-control, individuality, negotiated goals **(Customisation)**	2	5	12	1		2			2	**24**
Joint responsibility, social negotiation, team approach, peer evaluation **(Collaborative learning)**		5	10	1	4	1			2	**23**
CDT, basic skills/methods, decontextualized skills **(Components)**	4	4	2	4			4	2	1	**21**

Table 4.7.1 shows aspects from the cognitive family that are instructional/learning paradigms or characteristics of instructional systems. Table 4.7.2 indicates the high incidence of references to hybrid paradigms and cross-paradigm approaches extracted by the effectiveness criteria, as well as two other issues that feature strongly, namely, context and technology itself.

Table 4.7.2 Consolidated references to other issues										
Category	**Criterion and its associated table in the 4.6 series**									
	1 **4.6.1**	**2** **4.6.2**	**3** **4.6.3**	**4** **4.6.4**	**5** **4.6.5**	**6** **4.6.6**	**7** **4.6.7**	**8** **4.6.8**	**9** **4.6.9**	**Total**
Cross-theory/discipline, different methods at different times **(Cross-paradigm / hybrid paradigm)**	12	1		12						**25**
Contextual learning (**Context)**		2	3				1		3	**9**
Technology as a tool, to support, no-significant-difference (**Technology)**								8		**8**

4.4.4 Discussions of results of textual filtration

As already stated, the textual data in the 4.5 series of tables and their respective summaries in the 4.6 series, emerged as the result of filtration through effectiveness criteria. Tables 4.7.1 and 4.7.2 were then generated by taking the groups of characteristics and theories listed in the left columns of each of Tables 4.6.1 - 4.6.9, analysing them, and synthesizing them into categories. Each category was given an appropriate, succinct umbrella-type label. This section discusses the naming process and the tables, addressing Table 4.7.1 in Section 4.4.4.1 and Table 4.7.2 in Section 4.4.4.2 respectively. Section 4.4.4.3 briefly shows aspects from the behavioural family that also resulted from textual filtration.

4.4.4.1 Learning theories and characteristics of instructional design/practice

Table 4.7.1 was generated by combining related sub-totals from tables in the 4.6 series. It was found that most of the elements in the 4.6 series fall into six major categories of aspects of learning theory and instructional design, each of which has been allocated a label, indicated in bold print underneath the aspects that comprise the category. The labelling process was indisputable in three of the categories, namely: **constructivism**, **cognitivism** (or cognitive learning), and **collaborative learning** - all coincidentally commencing with the letter 'C'. The other three categories suggested alternative valid labels, but in each case, one of the possibilities was a C-word, and these were selected in order to be consistent. The first of these other categories addresses affective and motivational aspects, as well as the issue of creative instruction, which relates strongly to motivating learners, hence the decision to term the category **creativity**. Another involves concepts such as learner-control, learner-centricity, customization and individualization, suggesting the candidate labels *customization* and *learner-centricity*, of which **customization** was chosen. Customization is a stronger term than learner-centric, since it is possible for an instructional system/event to be centred on learners, yet not easily customizable to the individual. The final category relating to CDT and the basic knowledge, skills and methods inherent in every domain was more complex to name. However, due to the role of Merrill's component display theory and Reigeluth's promotion of the use of components within the 'new paradigm', the term **components** was chosen.

The researcher compositely terms this compact and concise set of six stances the **Hexa-C Metamodel**. It is not a model as such, since it does not propose nor represent any rigid process or system. Rather it is a set of strongly inter-related stances, most of which are associated with the cognitive paradigm, in line with the requirement in Chapter One that the theories and characteristics come from the cognitive family (although the methods of teaching basic skills originally emerged from behaviourist instruction). It is called a metamodel – a model of models, since it is a **synthesized framework comprising six inter-related, overlapping, and composite elements**, each of which was generated by the selection criteria.

The elements of the metamodel are therefore:

1. *Cognitive learning theory*: A fairly self-evident class - relating to cognition, cognitive psychology, and cognitive learning; as well as the fruit of cognitive processes such as mental models, HIP, metacognition, self-regulation, and integration, etc;
2. *Constructivism*: The major category - which relates to tenets such as knowledge construction, active learning, anchored instruction; also to constructivist implementations of learning such as problem/project-based learning, open-ended learning environments, authentic tasks, and complexity; as well as associated fields like chaos theory, flexible instruction, and learning within ill-structured domains;
3. *Components*: A category that incorporates aspects of component display theory, also all mention of basic skills and methods - entailing unitary components and composite components, as well as decontextualized skills;
4. *Collaborative learning*: Incorporates references to cooperative learning, joint responsibility, social negotiation, team approach, and peer evaluation;
5. *Customization*: A broad category - including all reference to learner-centric instruction, learner-control, and negotiated goals; in addition to the more obvious connotations of individuality and personalisation and customized learning; and
6. *Creativity*: Another wide group - combining assertions regarding motivational and affective aspects, intrinsic motivation, the engagement of learners, creative and innovative strategies, and the affective-cognitive bond.

The Hexa-C Metamodel (HCMm) is thus a framework that suggests sound characteristics of and underlying foundations for learning events and environments. The consolidated totals in Table 4.7.1 show constructivism (total 42) as the dominant paradigm resulting from the selection process, followed by the other five Cs within close range of each other (scores of 27, 24, 24, 23 and 21). The framework of the HCMm can be used as a design aid and can also be applied within evaluations of existing learning resources, courses and interactive learning environments, to investigate them from the perspective of instructional and learning theory.

4.4.4.2 Further aspects of learning, including context and technology

Some of the groups of characteristics generated by the 4.6 series of tables do not relate directly to a specific learning theory/philosophy or characteristic of instructional systems design. These groups were similarly combined under umbrella-labels, and the figures in the columns of Table 4.7.2 were determined by adding together related sub-totals from the associated rows in the 4.6 series of tables. They were categorized under issues of **hybrid paradigms**, **context**, and **technology** respectively.

- *Hybrid paradigms*: The aspect of transcending paradigms emerged strongly from the textual filtration process in three of the categories, including twelve mentions under Criterion 4, the learning-focused category . 'Hybrid paradigm', in and of itself, is not a theory or a characteristic to be incorporated in the metamodel. However, the fact that so many sources advocate cross-paradigm fertilisation or combinations is a confirmation of the intention of this study, and underscores the integrated nature of the elements of the framework.
- *Context*: Contextualized learning is shown to be of great value. The concept of 'context' is thus used in the HCMm as a meta-context, in that the environment in which the framework is to operate is that of contextualized learning - the context dynamically being each domain within which the HCMm is applied.
- *Technology*: The HCMm can be used independent of technology and can be applied to investigate any learning product or -experience. However, most current learning occurs in environments that use technology and multimedia, and technology-based learning is an innate assumption of this study. Technology is thus the hub of the framework, since it relates to each of the six C-elements.

4.4.4.3 Aspects of learning theory from the behavioural family

One of the groups generated from the 4.6 series of tables relates to aspects of explicit objectivist behaviourism. The concepts in this group, shown as a single row in Table 4.7.3, are mostly excluded from the metamodel, since the integrated stances, as required in Chapter One, Section 1.2 are to be current theories and practices of learning/instruction and from the cognitive family. The researcher's approach, shown in Table 4.7.1, however, does incorporate certain cross-paradigm aspects that originate from behaviourist instruction, for example, the role of basic knowledge and skills.

Table 4.7.3
Consolidated occurrences of concepts from the behavioural family

Characteristic	Criterion and its associated table in the 4.6 series									
	1 **4.6.1**	**2** **4.6.2**	**3** **4.6.3**	**4** **4.6.4**	**5** **4.6.5**	**6** **4.6.6**	**7** **4.6.7**	**8** **4.6.8**	**9** **4.6.9**	**Total**
Objectives, stimulus-response, Gagné's events of instruction, observable behaviour, objectives used for testing, criterion-referenced tests (**Behaviourism**)		5	3		7	1	1			**17**

4.5 Elements of the Hexa-C Metamodel

The criterion-based textual filtration process of Section 4.4 delivered six categories of learning and instructional concepts, each of which was consolidated into a single term/ label that aptly represents the category. The six labels became the elements of the framework of the Hexa-C Metamodel, representing aspects that are shaping current dynamics in learning and instructional design. As well as theoretical perspectives, the framework includes practical factors relating to design and delivery of instruction.

Before proceeding to apply the metamodel in Chapter Five and amplify its elements in Chapter Six, the researcher set out to determine whether the single labels selected to represent the various categories, in and of themselves (along with their connotations/denotations), **generally comply with the selection criteria**. In Section 4.4 the criteria delivered the categories and in this section, conversely, the category labels - in their pure, rather than representative forms - are examined against the criteria. Section 4.5.1 briefly defines each element, culminating in a graphic representation of the integrated framework. In Section 4.5.2 each element is examined against the nine selection criteria; this is set out in Table 4.8.

4.5.1 The six elements: singly and compositely

1. Cognitive learning theory

Cognitive science views learning as a process that supports cognition, formation of internal knowledge structures within the learner, and retention. Cultivating cognitive processes is seen as more important than generating learning products. Critical thinking skills are fostered in learners in the context of authentic problem solving or by explicit teaching of cognitive strategies alongside content knowledge.

2. Constructivism

Constructivism is not direct instruction; rather, it entails setting up learner-centric environments and activities. The aim is to instil personal goals and secure active involvement in knowledge construction within real-world situated learning, resulting in the type of knowledge attainment that results in applicatory skills, and effective transfer. It emphasizes collaborative activities and learner-research using a wide variety of multi-media resources.

3. Components

Component display theory (CDT) (Merrill, 1983) examines whether the instructional strategies used in a learning event can effectively achieve its instructional goals. However, the choice of 'components' as an element of the framework goes beyond CDT, in that it relates to the basic knowledge/skills of a domain.

4. Collaborative learning

Collaborative learning involves joint work, sharing responsibility within a group. It optimizes on complementarity and instills collaborative skills in learners.

5. Customization

Customized learning aims for instruction that adapts to individual learners' profiles, supporting personal processes and products, and allowing learners to take initiative with regard to (some or all of) the methods, time, place, and content of their learning. It supports the ethos of matching learners' needs and interests within the context of instruction/learning.

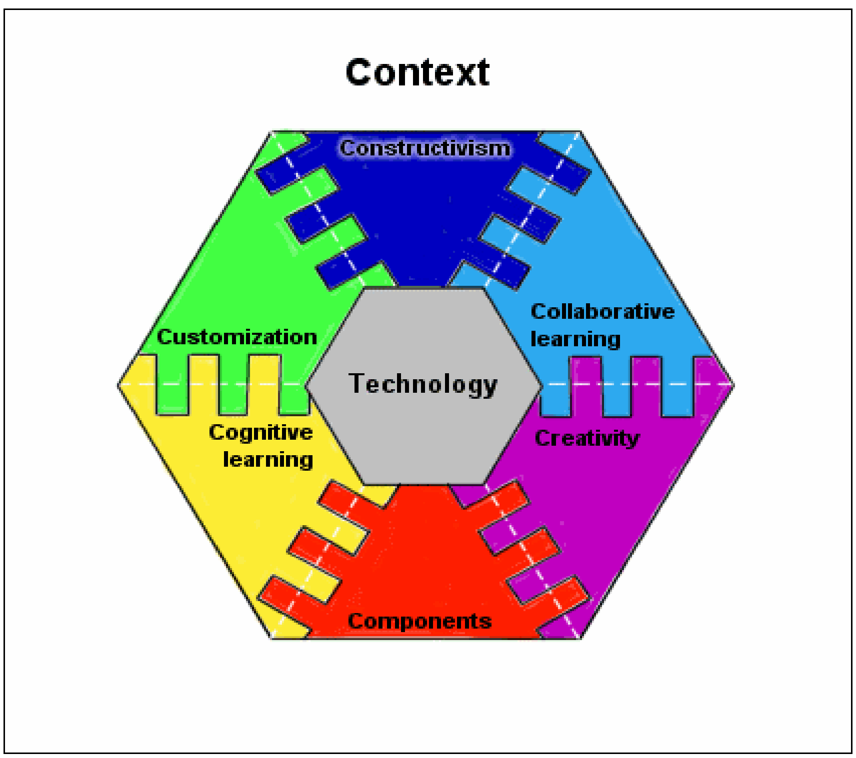
5. Creativity

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

Graphic representation of the Hexa-C Metamodel framework

Figure 4.1 depicts the framework of the Hexa-C Metamodel, giving an indication of how the six elements merge and integrate. The dynamics of the theory-practice situation differ from one domain to another, hence the situation of the framework embedded within each *context*. The hub of the framework is *technology*, and concealed beneath 'technology' in the diagram are further central points of convergence and areas of overlap. If Figure 4.1 was a 3-D representation, further rich interrelationships could be portrayed - interrelationships which are discussed further in Chapter Six.

Figure 4.1 The framework of the Hexa-C Metamodel



4.5.2 The elements of the HCMm: examined against the effectiveness criteria

In the pull-out section following, Table 4.8 examines each element against the selection criteria.

Table
The six elements of the Hexa-C Metamodel

Selection criterion	Cognitive learning theory	Collaborative learning	Components
1. Consensus-builder: can be used in situations that transcend paradigms	Arose due to weaknesses in Skinner-behaviourism - leading to cognitive revolution. Later, contributed towards the emerhgence of constructivism, as the emphasis moved from knowledge assimilation to knowledge construction.	Intrinsic part of constructivism, but collaboration and particularly, cooperation can be used with all approaches.	Used in behaviourist and cognitive instruction. Not part of the constructivist paradigm, but may be appropriate for use in direct instruction of well-formed topics that precede constructivist learning.
2. Demonstrates utility: in authentic teaching situations, even if not research-proven	The various Merrill models have had a broad general impact.	Preparation for the real world	Not usually – components are often taught in a decontextualized setting.
3. Learning-focused: with learners' interests predominant	Intrinsic purpose is to enhance learning.	Working in teams is an integral part of Reigeluth's learning-focused theory.	Allows learners to chooses both the content components and type of performance
4. Pragmatic: complies with pragmatic, rather than theoretically idealistic considerations	Aims to guide and support cognition and for cultivation of cognitive processes within learners.	Yes	Yes, communication of components is done using a wide variety of instructional strategies.
5. Assessment: conforms to the general requirement that formal instruction incorporates grading / external assessment	Usually	Group assessment is a recognised form of assessment - usually entailing a group mark; may be supplemented with peer- and/or self assessment.	An integral part of the system; Objectives and assessment are frequently designed together.
6. Cognitice-affective: integrates affective and cognitive aspects	This is inherent in the more recent works on cognition.	Learners gain self-confidence by stating viewpoints and sharing knowledge. Less-able learners learn from peers.	Often aims to achieve the four aspects of the ARCS model
7. Complexity: has means of communicating complexity	By integrating new knowledge into existing cognitive structures.	Social negotiation helps to unravel complexity.	By breaking into various types of content information and types of performance/ activity.
8. Technology-wise: platform-independent	Yes	Yes	Yes
9. Prepares learners for real-world use	Supports contextual learning.	Preparation for real-life	Not directly

4.8 examined against the nine selection criteria		
Constructivism	**Creativity**	**Customization**
Extreme constructivism is intolerant of other paradigms, but moderate constructivism incorporates aspects and strategies that co-exist with other approaches; in particular it is in harmony with cognitive learning. Constructivism is founded on the tenet of personal experiential learning.	There is scope for creative product and environment design across the spectrum of learning theories.	Customization transcends boundaries and is practiced across the spectrum: it occurs in behaviourism by branching and adaptivity (program-controlled); it is inherent in ITSs (AI) which address individualisation by student models; CDT individualises by learner-control in selecting content and performance type; cognitive learning systems include branching, often student-controlled
Moderate constructivism is impacting increasingly on education in the form of project-based learning and -assessment.	Yes, provided that 'bells and whistles' special effects do not distract from the primary instructional purposes.	Very common
By definition - in particular by providing multiple perspectives on the topic.		Its basic purpose is to produce learning directed toward the individual
Not always	Usually	Depends on the application domain
Constructivism subscribes to assessment which differs from the conventional forms.	N/A	N/A
Recognises intrinsic motivation.	The main purpose of creative instruction is to motivate, engage and engross learners	Learner-control increases the affective and motivational utility of a learning experience
Learners are explicitly exposed to complexity; however, educators should ensure that support is provided in managing complexity.	The process of communicating complexity can well give rise to creativity.	Learners frequently find their own way through complexity.
Yes	Yes	Yes
Real-world value is an explicit goal.	Depends on the application	Depends on the application

The examination in Table 4.8 preceding indicates how the different elements of the metamodel fulfil different roles in meeting the nine selection criteria. All these may not necessarily be present at the same time, and a researcher would do well to make a selection of appropriate requirements for a particular instructional system / learning event, which, in turn, would be reflected by greater emphasis of certain C-elements within that system/event/environment, according to its requirements, subject domain, and context.

Various ways of implementing the six different elements of the framework are addressed in Chapter Six.

4.6 The Hexa-C Metamodel compared to Duchastel's challenge for a single theory of ID and Reigeluth's new paradigm of ISD

In Chapter One, Section 1.4.3, it was stated that *Reigeluth's new paradigm of ISD* (Sections 2.6 and 3.6) and *Duchastel's call for a full theory of instructional design* (Section 3.7) were catalysts for this study.

This study cannot be viewed as proposing a single, full theory of instructional design in response to Duchastel's (1998) challenge. The proposed framework, though useful for instructional designers and instructor-designers, is not a single theory of instructional design - it is not even a partial theory, since it does not attempt to propose any systematic model for the preparation of instruction and training.

However, it does represent an attempt to identify a set of theoretical and practical features as characteristics desirable and appropriate for effective learning and instructional environments and products, in line with the ethos of Reigeluth's new paradigm (1996a; 1996c; 1999). In view of this, Table 4.9 compares and contrasts aspects of the HCMm with Reigeluth's new learning-focused paradigm and Duchastel's prolegomena.

Table 4.9 Comparison and contrast: Hexa-C Metamodel, Reigeluth's new paradigm, and Duchastel's prolegomena			
Aspect	**Reigeluth's new paradigm**	**Duchastel's prolemena**	**Hexa-C Metamodel**
Goal	Learning-focused instructional theory, as well as broad variety of instructional-design theories and models in Reigeluth's Volume II (1999)	Calls for a full and comprehensive theory of instructional design to cover all domains and encompass all processes.	Integration of theories and practices from cognitive family to support effective learning. To be generally applicable to learning environments and materials/resources.
Defines instructional design theory as	Instructional design theory is concerned with characteristics of the instruction and its methods, not with processs used to develop instruction	A theory of instructional design is an organized set of prescriptions to help with preparation of instruction, i.e. a procedural model for planning execution of instruction.	Supports the Reigeluth view; Hexa-C is not an organized set of principles for the preparation of instruction - rather it comprises a set of inter-related stances and characteristics for effective learning.
Theory-method relationship	All the theories implement the basic methods, but by variable strategies and methods, cross-paradigm, using different terms. New theories should not replace predominant paradigms but should incorporate their strengths.	Rejects pluralism & calls for single theory. In particular, behavioural, cognitive, and constructivist learning should be integrated into a compre-instructional design theory.	Uses techniques and skills so as to transcend paradigms
Stance on learning	Learning is accomplished in environments that provide: Challenge under guidance; Empowerment with support; Self-direction within structure.	Learning theory is a descriptive science for learning processes, with scope for potential unification, which could facilitate associated consolidation in ID theories.	Moderate constructivist persuasion; tempered by the guidance stance of cognitivism.
Key features and methods	Customization, individualization, autonomy, and learner-as-king; Cooperative relationships, shared decision-making, and networking; Diversity and learner-initiative; Holistic approach; Process-oriented	Motivation achieved inherently, by means of authentic instruction that capitalises on natural curiosity.	Customization, learner-centric; Collaborative learning; Creativity and novelty; Uses components to teach basic knowledge and skills

Table 4.9 Comparison and contrast: Hexa-C Metamodel, Reigeluth's new paradigm, and Duchastel's prolegomena (continued ...)

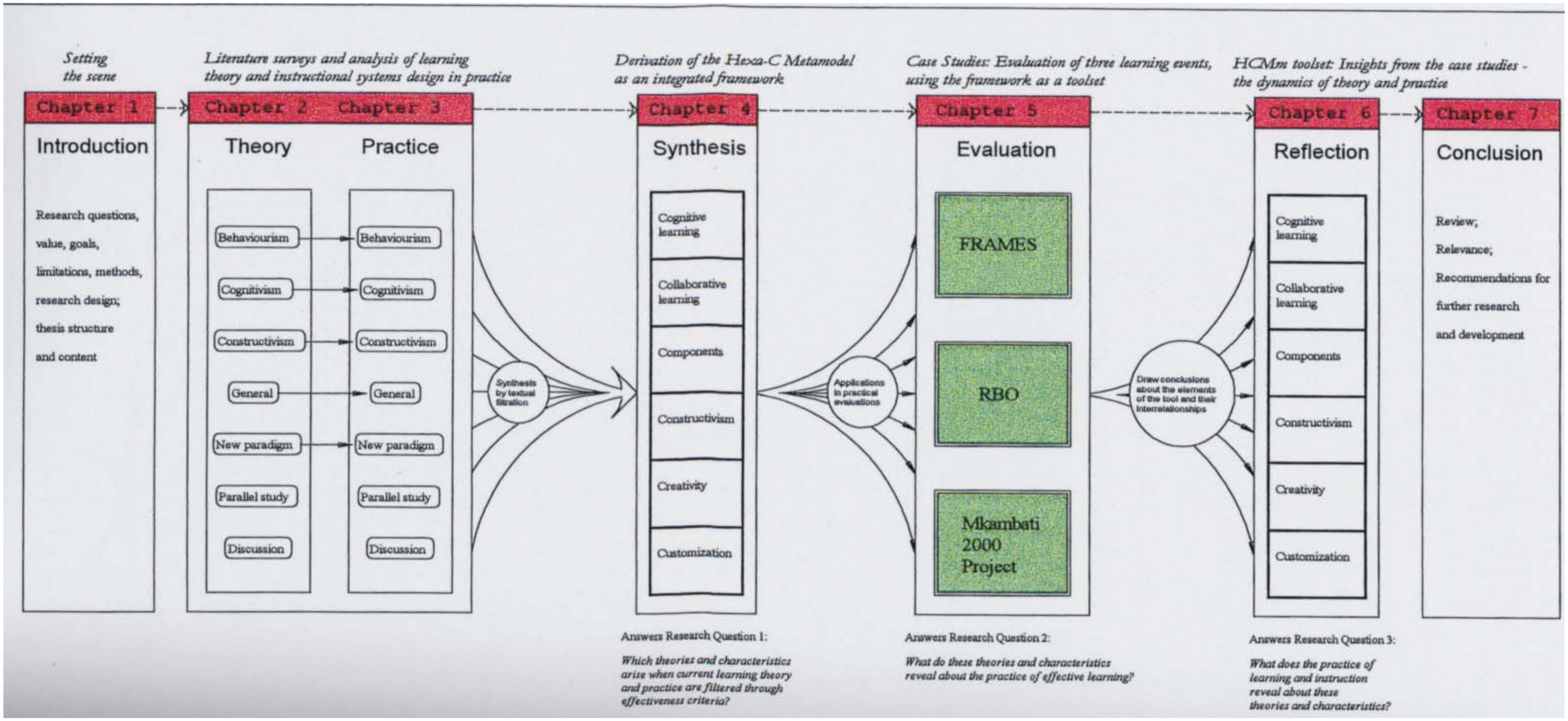
Practice of learning	Learning-focused theory should use the wide variety of current methods (PBL and project-based) as well as earlier (tutorials, simulations, etc.) Decisions taken during instruction	Certain goals are best accomplished by strong sequencing and high control; others require flexible, less rigid instruction. Key decision: when to switch?	Uses basic methods and components to achieve automaticity in subskills and knowledge units. Strong constructivism in appropriate situations
Roles	Roles of designer and teacher converge. User-designers (learners and facilitators) play decision-making role in designing and creating learning environments and materials.	Instructional designer to remain clear of content decisions. Subject-matter expert and instructional designer are different persons; there is no mention of user-designers.	Optimally, designer and facilitator are same person, i.e. an instructor-designer, rather than an instructional designer.. Users are designers in selecting content and strategies from options
Beliefs and values	Philosophies and values influence learning goals and methods used. Diversity of values results in different instructional approaches. Different kinds of learning should be addressed - such as character education, attitudes, HOTS and cognitive strategies	Differences between paradigms are due to the underlying values of theorists. This influences what is taught, beliefs about learning, and views on instruction.	Proposes cross-paradigm use of stances: - Integrating where appropriate; and - Using in tandem for different kinds of learning, where appropriate.
Ideal theoretical approach	The variety of learning-focused theories in Reigeluth Volume II (1999) allows practitioners to select theory or model that best fits the situation.	Principles to determine a single theory of ID: Determine and explain nature of learning. Characterise process and products that shape learning experience. Subjugate content to instructional function without artificial motivation. Form general rules of instruction. Situate and confront - as an integral part of scientific progress.	Accepts the separate existence of various theories but defines a model (or abbreviated theory) to integrate the strengths of learning-focused theories.

4.7 Conclusion

This chapter has discussed underlying theories and characteristics of learning experiences that support effective learning and facilitate the task of the educator. The study is aimed at the context of educational practice with its contemporary pervading themes of social learning; authentic problem-solving; and interactive technology, both as a tutor and as a tool. Based on studies of the literature and textual filtration techniques, Chapter Four proposed an answer to the first research question in Chapter One, by putting forward a compact synthesis in the form of a framework of theories and characteristics that emerged when current learning/instructional theory and characteristics of practice and learning experience were filtered through effectiveness criteria. The resulting framework, called the HexaC Metamodel, comprises six interrelated and synergistic theories and stances, namely: cognitive learning, collaborative learning, components, constructivism, creativity, and customization.

The prime focus of the HCMm is interactive learning, frequently via online, technologically-enabled learning experiences and resources. It is also applicable to learning events not necessarily delivered via, or mediated by, computer or the Internet, but where learners use technology as tools and facets of general learning. With this in mind, Chapter Five presents case studies in which the Hexa-C Metamodel, with its constituent elements, is applied to three learning events to evaluate them from the perspective of learning theory.

Structure of the thesis



Chapter Five

Evaluation

What the HCMm toolset reveals about three learning events – case studies

5.1 Introduction

The framework developed in Chapter Four, namely the Hexa-C Metamodel (HCMm), is applied in three case studies as a set of tools to **evaluate three different learning and instructional events** from the perspective of learning theory / instructional practice. Investigations are conducted to determine how the instructional design of each fulfils its requirements and solves the problem it sets out to address. Studies are undertaken of:

1. FRAMES, a computer-based interactive practice environment,
2. RBO, a web-based course, and
3. The Mkambati 2000 Project, a field trip/project in the subject of Ecotourism.

The inquiry undertaken in this chapter answers the second research question in Chapter One:

> *What do these theories and characteristics (i.e. the theories and characteristics of the HCMm) reveal about the design and practice of effective learning?*

The chapter has three major sections - Sections 5A, 5B, and 5C, for the three case studies respectively. The studies demonstrate the versatility of the HCMm, in that while Section 5B examines an entire course, the other two address specific aspects of courses, as indicated in Table 5.1.

5.1.1 The three learning events

The learning events investigated were chosen due to the researcher's close involvement with, and hands-on participation in, each one. Within the three sections, 5A, 5B, and 5C, certain aspects are repeated, so that each case study is complete in itself.

Table 5.1 summarizes the purpose and main features of the learning events, prior to the detailed evaluation and discussion of each study.

Table 5.1 Introduction to the three case studies			
Aspect	**Case study**		
	1. FRAMES (Chapter 5A)	**2. RBO (Chapter 5B)**	**3. Ecotourism fieldwork and project (Chapter 5A)**
Academic domain	Mathematical concepts in an undergraduate course, part of a BSc degree in theoretical computer science	RBO, a postgraduate course in Internet-based learning, part of a masters degree in computer-assisted education	Postgraduate course in Ecotourism, taken as part of various honours and masters-level degrees
Learning event analysed in the study	FRAMES, an interactive practice environment, used as a supplementary learning aid	The entire web-based RBO course	The practical fieldwork and project-based part of the Ecotourism course
Real-world problem addressed by the learning event, i.e. the general purpose	To provide support for isolated distance-learners, tackling hands-on practice of mathematical skills	To train educators in: - Presenting courses on the Internet, and - Using the Internet to manage resource-based learning and distance-education	To supplement theory and case studies presented in a class situation with practical hands-on field work
Aim of the instructional design, i.e. the particular strategy of the designer	To produce a 'virtual tabletop' providing the objects normally lying on students' desks when they do exercises, and to offer an 'androgogic activity box' of options to practice	To place the educator-cum-learners in position of Internet-based learners, giving them first-hand experience of the receiving end of an Internet course, and doing so in a web-based 'classroom'	To tackle a real-life problem *in situ* and to present solutions collaboratively
Use of computers	Computer-based interactive practice environment	Internet and Web-based course	Computers used as tools.
Date evaluated	1997, 1998	2000	2000
Relationship of researcher to the event, prior to and during the investigation	Lecturer of the course and designer of the FRAMES computer-based environment	Learner-observer, a student throughout the duration of the 2000 RBO course	Participant-observer, present throughout the Mkambati field trip

5.1.2 Research methods for evaluating the learning events

Basic systematic instruction is traditionally investigated empirically. However, reductive, experimental, quantitative research methods are not the most appropriate for evaluating problem-based learning and team-learning. Moreover, constructivist learning does not lend itself to research-based empiricism (Section 3.8; Willis, 1998). This research design is therefore non-experimental.

For the evaluations in this chapter, **qualitative ethnographic research methods** were used within an overall approach of action research (as described in Chapter One, Sections 1.4.1, 1.4.2 and 1.6.4), combined with limited quantitative data. Ethnographic research entails **investigation in natural settings, in-depth understanding of a situation, and personal involvement of the researcher in situations where he/she cannot exercise scientific control**. The **qualitative** evaluation approaches - data collection by questionnaires, observation, and interviews - elicited rich **descriptive information**, which presents holistic and interpretive pictures of the three learning events. Open-ended questions allow learners to substantiate and amplify their responses.

The surveys differed for each case study. The initial 1997 evaluation of FRAMES was a general survey, not specifically from the perspective of learning theory, while the follow-up interviews in 1998 were more focused on this aspect. Though not initially undertaken for the purposes of this thesis, the FRAMES data provides valuable input for the study. The survey of the RBO learners in August 2000 and the Mkambati evaluation in November 2000 were explicitly undertaken as part of this research and were evaluations from the perspective of learning and instructional theory/practice. The RBO questions were incorporated into a joint survey by two researchers, with each researcher extracting her data of interest. The Mkambati questionnaire was based on pertinent questions in the RBO survey, but expanded. Moreover, the RBO and Mkambati questionnaires were both contextualized to the specific learning event. All the questionnaires and the interview structure are available in appendices, but relevant questions are also included in each subsection.

Processing of descriptive, qualitative data involves careful assimilation and analysis of answers, and manual classification of open-ended responses. The process is labour-intensive and time-consuming, but with the small group sizes, was manageable for the researcher:

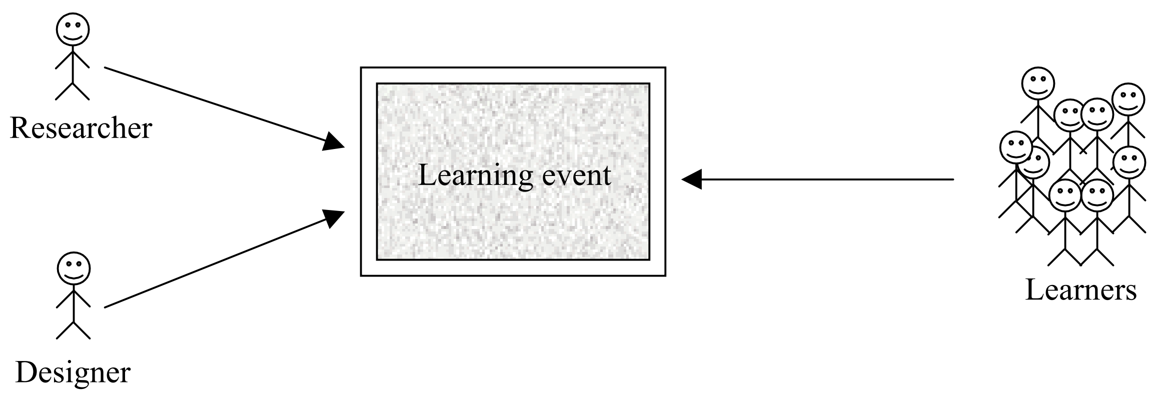
1. Case Study One : a sample of 18
2. Case Study Two: population of 22
3. Case Study Three: population of 12

Inquiry into the events, in turn, generated considerable further information about the evaluation tools, i.e. the elements of the metamodel and ways they can be applied to support effective learning. This is discussed in Chapter Six.

5.1.3 Structure and nature of learning event evaluations

Each of the three investigations is structured according to a consistent format, comprising six major sections - evaluating the learning event **according to the six elements that comprise the framework of the Hexa C-Metamodel**, namely: constructivism, cognitive learning theory, component theory, collaborative learning, customization, and creativity. Under each of the six element headers, there are three subsections analyzing the event from the perspectives of the researcher, designer, and learners, respectively, as shown in Figure 5.1.

Figure 5.1 Evaluation perspectives:
How each element is used to investigate each event from three perspectives



1. First, in the 'Initial discussion' subsection, the *researcher* discusses aspects of the event that comply with characteristics of that element of the metamodel, also investigating each case for features in line with appropriate theories and models introduced in Chapters Two and Three.
2. The second subsection presents the viewpoint of the *designer* of the learning event/resource, acquiring his/her overall impression on whether and how that HCMm element was implemented. These are presented in an informal, conversational style, based on interviews and consultations.
3. The third perspective presents data from the researchers' survey of the *learners*, incorporating appropriate extracts from the questionnaires. (As stated in Section 5.1.2, surveys differed for each case.) An interesting aspect of learners' responses to open-ended questions is that, as well as answering questions directly, many responses reinforce the inter-relatedness of the HCMm elements. For example, an answer to a question about customized learning may refer explicitly to creativity, and answers to questions in several sections related directly to collaborative learning. In such cases, the information is incorporated under the header where it is most appropriate.
4. Each of the six sections concludes with a fourth subsection, which discusses important aspects revealed by that element of the framework - strengths and shortcomings of the learning event, and how it achieved/did not achieve its aims and objectives.

Finally, each of the three evaluations concludes by relating the particular learning event and its wider context to Perkins' (1991a) facets of a learning environment (see Section 3.5.4), and by briefly re-iterating the role of technology in the event.

The credibility and validity of this research is enhanced by the extensive and participatory nature of the investigations. They were not the minor interventions (30 minutes to an hour) which characterize some instructional technology studies (Clark, 1989, cited in Kozma, 2000). Rather, the researcher had ongoing involvements with the learning events, as described in Table 5.1. Furthermore, the research designs (Sections 1.4.2, 1.5.2, 1.7.1, 1.7.3 and 1.7.5; see also 'grounded theory development' - Section 3.8.2), gave the researcher freedom and flexibility to investigate promising and unanticipated avenues within the study, rather than treating them in a *post-hoc* fashion or suggesting a new study.

The rest of this chapter is subdivided into three major sections for the three case studies - each complete in itself - as it sets out the detailed evaluation and discussion of a learning event:

1. Section 5A – FRAMES,
2. Section 5B – RBO, and
3. Section 5C – the Mkambati 2000 Project.

Section 5A - *Case Study One: FRAMES*

The first case study relates to FRAMES, an interactive practice environment for mathematical concepts in theoretical computer science (De Villiers, 1995; 1998; 2000). FRAMES is investigated using the Hexa-C Metamodel to determine whether and how the instructional design of the learning event achieves its purpose. In the first part of Section 5A, the module and its context are outlined, then the content and *modus operandi* of FRAMES are described.

The next and major part of Section 5A is devoted to discussion, evaluating the practice environment according to the six 'C' elements that comprise the framework of the HCMm. Within each section, FRAMES is examined for its application of the appropriate learning theory or characteristic. As explained in Section 5.1.3, each section is further divided into three perspectives:

(i) Initial discussion by the *researcher*;

(ii) viewpoint of the *designer* of the learning event (who is an *instructor-designer*); and

(iii) *learner-data* - quantitative, but mainly qualitative, obtained from surveys and interviews;

before ending with a *concluding discussion*.

Note: The set of second perspectives in this evaluation (information from the designer's viewpoint) contains little information since, as stated, the researcher and instructor-designer are one and the same. There would be little value in repeating information already supplied in the first subsections.

5A.1 Introduction to FRAMES

5A:1.1 Immediate domain and purpose

FRAMES is a prototype version of an interactive practice environment for a first-level undergraduate BSc module in Theoretical Computer Science (COS101-S) at the University of South Africa. The module covers relevant mathematical concepts from the field of discrete mathematics, whereas other first-level Computer Science modules are oriented toward characteristics of computer systems and fundamental programming concepts. The section involving analysis of infinite relations and their properties has consistently been difficult for the target group. The FRAMES practice environment covers this section of mathematical manipulations on infinite relations, representing approximately 10 - 15% of the module syllabus (De Villiers, 1995). The package is called F R A M E S, because the R, A, and M represent a Relation, an Attribute and a Mode, respectively, the three choices a learner makes when selecting an activity or an aid component from the environment.

FRAMES is not a tutorial; it is a supplementary learning aid, which prompts, supports and makes help accessible as learners tackle problem-solving exercises hands-on. As indicated in Table 5.1, FRAMES has both a general purpose and a specific design aim, namely, to support isolated distance-learners by simulating a 'virtual tabletop' in its design. It is intended to provide the reference objects needed for a meaningful practice session, as well give feedback and guidance.

5A.1.2 Greater environment and learners

The greater environment of FRAMES is the University of South Africa (Unisa), one of the ten mega-universities of the world. Unisa is a distance-teaching institution with over 110 000 students. Headquarters are in Pretoria, the capital city of South Africa. It caters largely for mature learners, some of them taking first qualifications and others enrolled for continuing education. Approximately 30% of students are 25 or younger and only 20% study fulltime. Tuition is handled mainly by correspondence; in general, students receive their tutorial matter and submit assignments by mail.

The university is a needs-driven pioneer in the development of instructional multi-media, as printed instruction is increasingly supplemented by educational technology, such as radio, audio-casettes, video, computer-aided instruction (CAI), and more recently, by certain Internet-based facilities. Due to the disadvantaged, technologically-illiterate nature of some of its students, as well as the fact that many live in remote areas, Unisa has not been at the forefront of Internet- and Web-based instruction - but is increasingly migrating in that direction. Students with technological means can obtain information from the website, register and make administrative queries on the Internet, as well as submit assignments on-line. Lecturers can be reached by telephone and e-mail for academic queries.

Approximately 1000 distance learners take COS101 annually, with a high attrition rate reducing enrolment to about 600. As a first-level undergraduate module, it has higher enrolments of young students and fulltime students than the university's general profile, in that 50% of its students are 25 or younger, and 30% study fulltime. They mainly use conventional mail to submit assignments.

5A.1.3 Roles: the FRAMES designer, lecturer, and researcher

The researcher, who has a multi-disciplinary background in mathematics, computer science and education, is the current leader of the lecturing team for the module, COS101. She did not write the initial course material, but is the creator of FRAMES - having developed the concept and designed the practice environment, i.e. she is both lecturer and designer (De Villiers, 1995). In this evaluation she has a triple role, also being an action-researcher investigating an artifact of her own design. The product was custom-built and coded in the programming language *TENcore* by staff of the Centre for Software Engineering (CENSE), based in Unisa's Department of Computer Science.

5A.1.4 Material and approach of the FRAMES practice environment

Text Box 5A outlines the mathematical content of FRAMES and describes the way in which the computer-based program is used. It also describes how the learner evaluations were conducted.

Text Box 5A Subject matter and modus operandi of FRAMES and the FRAMES learner-evaluations

Why the name, FRAMES?

In CAI terminology a 'frame' refers to a screen presentation. The central acronym, RAM, within FRAMES is significant, because learners using the environment select instructional components by so-called RAM control, selecting (i) a Relation, i.e. a specific mathematical relationship as the scenario for their practice, (ii) an Attribute of that relation, and (iii) a performance Mode.

The goal of FRAMES

The goal of FRAMES is to use ID principles to produce a practice-environment, a metaphorical 'andragogic activity box' providing various instructional activities and feedback on learners' efforts. Its human-computer interface is represented by a further metaphor - a 'virtual table-top', providing the objects (diagrams, definitions, worked examples, etc) that would lie on students' desks during typical problem-solving sessions.

FRAMES assumes subject-matter grounding in the simpler discrete relations, as it addresses analysis of the more complex infinite relations. It was designed to offer extensive and intensive practice opportunities in subskills and composite problem-solving skills, to present visual aids, to offer help and feedback, and to increase general domain-familiarity, all within the context of specific examples. It was built (De Villiers 1995, 1996; Kotze & De Villiers 1997), using the authoring language TenCORE 5.0. This highly interactive environment entails innovative instructional strategies, and called for programming techniques new to Unisa. The requirements were imprecise, requiring testing and evaluation. Screen layouts evolved in a form-follows-function manner, rather than adhering to specifications or storyboards. Prototyping was the ideal development route, since it is conducive to modification of the approach and strategies.

Subject matter

The content of FRAMES is the domain of infinite relations. Each relation is a set of ordered (x,y) pairs with a specific relationship defined between x and y. As an example, consider the relationship where x divides exactly into y - some of the pairs in this relation are (5,15); (4,8); (10,70); ... etc. Understanding the relation is more complex than it would appear from the above simple example, because the relations are expressed as mathematical formulae and furthermore, each relation is defined on a specified domain, such as the set of integers, the set of rational numbers, etc. In an exam or assignment, students are expected to test the given relation to determine whether it satisfies certain properties, e.g. reflexivity, transitivity, and so on. They also tackle composite proofs, which integrate various tests to determine the 'kind' of relation. The FRAMES system was developed to provide support and practice in these skills.

How to use FRAMES

As mentioned, learners using FRAMES select activities and aids by R A M control; the choices are executed by clicking on appropriate buttons. Using on-screen control, they make three decisions when choosing a component "to view or to do":

1. **Which Relation to choose**

   Relations are sets of co-ordinate (x,y) pairs, where a specified relationship exists between and the x- and y co-ordinates. The relationship may be defined by a formula or by a textual description. The Relations included in FRAMES are called **P, Q, S, T, V, W,** and **TR,** where, to define some:

- **P** is the set on Z of all **(x,y)** pairs such that **x ≤ y**
  (where the domain Z is the set of integers { ... ,-2, -1, 0, 1, 2, ... }).
- **Q** is the set on Z of all **(x,y)** pairs such that **x - y = 3k**
  i.e. the difference between x and y is a multiple of 3.
- **S** is the set on P of all **(x,y)** pairs such that **x | y**
  i.e. x is a factor of y, and y is a multiple of x
  (where the domain P is the set of positive integers {1, 2, 3, ... }).

   On selection of a relation, its definition component appears on-screen as a 'blackboard'.

2. **Which Attribute of that relation to view, apply, or test**

   The 'attributes' of each relations are **Examples** of that relation, a **Graphic** aid, opportunities to test a mathematical **Property** of the relation, and a composite problem relating to the overall **Kind** of relation:

- **Example** requires the learner to synthesize members of the current relation.
- The **Graphic** attribute shows a visual representation.
- **Property** attributes present mathematical tests for the properties of reflexivity, irreflexivity, symmetry, antisymmetry, transitivity, and trichotomy.
- The special **Kinds of Relations**, namely, equivalence relation, weak-partial-order, weak-total-order, strict-partial-order, and strict-total-order. In order to be one of a particular 'kind', the relation must satisfy a specific set of the properties named above. The facilities available in this category allow learners to view model analyses, or do independent testing themselves to determine whether the appropriate criteria are satisfied.

  Knowledge of the properties of each kind of relation is stored in the FRAMES knowledge base, so that the system can select the relevant set of property tests for the composite 'kind of' analyses, and check a student's selected set in the independent mode (see 3).

3. The choice between Modes **1, 2,** and **3,** for doing property and kind exercises, where

   Modes relate to the kind of presentation by the system / performance of the learner:

- **Mode 1** demonstrates a read-only proof, constructed step-by-step.
- **Mode 2** offers guided practice using fill-in-the-blank structures.
- **Mode 3** encourages independence, interspersing linking-structure with blank lines on

which learners input a do-it-yourself (DIY) proof.

The three modes cover the same content, but in different ways. Mode 1 sets out a complete worked proof as a model. In Modes 2 and 3 learners use keyboard-input and mouse-clicking to select mathematical characters from a symbol pad. Modes 2 and 3 also incorporate judgement, present feedback, and accept correct alternatives.

Learner-evaluations

Pilot-testing and evaluations of FRAMES were conducted in the Unisa context of distance education, with limited direct contact. A general tutorial letter sent to all students registered for the module in 1997 included a call-for-volunteers to try a prototype practice environment, and resulted in eighteen respondents. They lived in widespread regions, and represented an excellent spectrum of the heterogeneous students. The volunteers used FRAMES and completed learner-evaluation questionnaires in their study situations at home, at work, or in Unisa computer laboratories. Three discontinued the module, but of the remaining fifteen, fourteen completed questionnaires. The survey incorporated general aspects (outside the scope of this study), but was also aimed at aimed at evaluating FRAMES from the perspective of learning theory. There were highly structured questions where respondents could choose their rating from the available options, as well as open-ended questions and open-ended elaboration options. Triangulation, the use of data from multiple sources, was applied, in that the researcher held informal telephonic or personal interviews with about half the respondents, and investigated subsequent examination marks as a post-test.

A follow-up study in 1998 entailed in-depth, structured interviews with a few students. A tutorial letter extended a call-for-volunteers in Unisa's immediate locality, the Pretoria region, and resulted in four participants. These personal interviews focused exclusively on assessing the effectiveness of the application of learning and instructional theories.

Combining the volunteers from the 1997 and 1998 evaluations thus resulted in data from 18 learners.

Figure 5A.1 shows an introductory FRAMES screen, which presents the concept of R A M control to a learner, demonstrating the Relation, Attribute and Mode menus. The Relation menu offers a choice of seven relations, describing each by a formula that indicates its mathematical relationship. As the learner clicks on a menu, the selected item turns red. The screen in Figure 5A.1 also shows two pop-up elaborations, explaining, for example, the strategy of the Mode. On the activation of **GO** at bottom right, an operational screen would appear with the learner's selected activity/aid component.

Should a learner opt for the 'Kind of relation' component, he/she will undertake composite analysis, covering all the property tests required for the 'Kind' selected a attribute. Figure 5A.2 portrays the RAM selection - highlighted in red on the right hand control area - of:

i. <u>R</u>elation **P**;
ii. <u>A</u>ttribute **Kind** followed by the sub-selection of the **WPO** kind (weak partial order); and

iii. Mode **1** (read-only).

Figure 5A.1 A FRAMES introductory screen

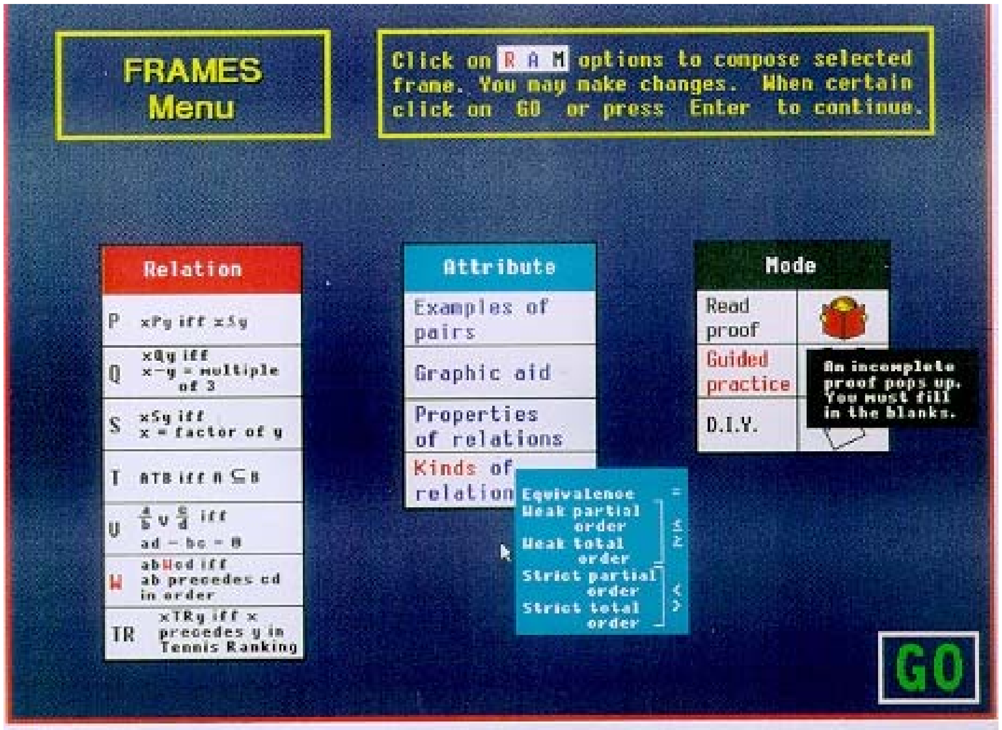


Figure 5A.2 A composite component for analysis of the 'Kind' of relation

5A.1.5 Research design of the FRAMES case study

As explained in the chapter introduction, Section 5.1, the evaluation has six major sections, devoted respectively to the six elements of the HCMm. Each has four subsections, of which the first three reflect different perspectives, and the fourth concludes the section:

The descriptive data in the first subsection of each, namely, the 'Initial discussion' subsections: 5A.2.1.1, 5A.2.2.1, 5A.2.3.1, 5A.2.4.1, 5A.2.5.1, and 5A.2.6.1, are qualitative discussions written from the perspective of the researcher. The data was generated by *qualitative analytical research*, investigating the case through analysis of an artefact - namely the computer-based FRAMES environment. The case study also falls into the *qualitative ethnographic research* category, since the researcher was personally involved as the designer of FRAMES and had extensive hands-on experience testing the system, as well as observation of and interaction with others who used it.

The set of second subsections, namely the 'Viewpoints of the instructor-designer', entailing 5A.2.1.2, 5A.2.2.2, 5A.2.3.2, 5A.2.4.2, 5A.2.5.2, and 5A.2.6.2, are incorporated to provide information from the perspective of the originator the learning event. As mentioned in the introductory comments of Section 5A, this section holds little information in the FRAMES study, since the researcher and the designer are the same person.

For the third set of subsections, 'Findings from the survey of learners', the methods used were mainly *qualitative, non-experimental empirical techniques*, the primary data collection method being a survey, supplemented by interviews. In the Unisa context of distance-education, learner-accessibility is limited, so a heterogeneous sample of fourteen volunteers (as explained in text box. 5A.1 above) was used for a *questionnaire survey* in 1997, which focussed on learner-evaluation of FRAMES from a general viewpoint, as well as from the perspective of learning theory. Some of the questions were multiple-choice, and responses to these have been statistically analyzed. A subsequent localised *in-depth interview survey* was conducted in 1998 with four other volunteer learners (of whom three were from formerly disadvantaged groups), focusing on the aspects covered by the HCMm. Appendix A1 contains the full questionnaire, and the core structure of the interview is in given in Appendix A2. Questions are also shown in appropriate subsections within the text. Thus FRAMES was pilot-tested and evaluated by a heterogeneous convenience sample of 18 students (De Villiers 1999b, 2000), the sample being a good representation of the COS101 learners of 1997 and 1998. Where responses are tabulated, percentages are not given due to the small sample size.

The *qualitative learner-data* provides insights into the ways that learners use FRAMES. The data was obtained from responses to open-ended questions and elaborations in the 1997 survey and from the 1998 in-depth interviews. In general, twelve of the fourteen who completed the 1997 questionnaire were very positive about FRAMES. Two expressed reservations in addition to praise, one of them an information technology professional. The four students involved in the 1998 interview survey did extensive practice with FRAMES, individually and collaboratively, and praised the learning experience highly. In some cases, learner-responses elicited in a certain category have been integrated into the discussion of another element of the HCMm, where they relate better and add value. As an example, certain information elicited from questions about 'components' is discussed under the header 'cognitive learning'.

Table 5A.1 shows profiles of the learners surveyed.

Table 5A:1 Profiles of learners surveyed (n = 18)				
Characteristic	**Subdivision**			
Gender	Female 5		Male 13	
Full-time / part-time	Full-time 9		Part-time 9	
Qualifications	Previous qualifications 3		No qualifications 15	
Ethnicity	White 10	Black 6	Coloured 1	Asian 1

5A.2 Investigating FRAMES - using the Hexa-C Metamodel

FRAMES is investigated with respect to the application of learning and instructional theory, using the elements of the Hexa-C Metamodel as a framework. As stated above, a section is devoted to each of its six elements. The sequence in which the elements are used as headers is not the same in each case study. Rather, in each case, the element whose associated investigation provides the most pertinent background information about that case, is addressed first. This sets the scene for the remainder of the study. Accordingly, component theory is used as the first heading in the FRAMES case study. Three of the elements (namely: component theory, cognitive learning theory, and constructivism) relate more to theoretical aspects and underlying philosophical implications, and are addressed as the first three of the six. The other three elements of the HCMm (customized learning, collaborative learning, and creativity) tend to be more practical characteristics of learning environments and events, and follow afterwards.

5A.2.1 Components

This section reports on component-based learning within FRAMES. Most forms of knowledge and skills comprise basic units (components), with which learners interact in different ways. They can:

- read, study and peruse them;
- discover them for themselves; or
- they can apply them, implement them and practice them.

COS101 involves theoretical knowledge of discrete mathematical concepts, and practical skills in applying that theory. This section investigates how FRAMES supports learners in comprehending the components of relations - involving basic theoretical units, problem-solving skills, and complex composite components. FRAMES is also compared to Merrill's Component Display Theory (sections 2.3.3.4 and 3.3.3.1; Merrill, 1983).

5A.2.1.1 Initial discussion

FRAMES is evaluated to examine the ways in which it addresses the basic components of its domain. FRAMES has a component-based structure (De Villiers, 1998), and was explicitly designed according to CDT, based on the two dimensions of performance and content (Sections 2.3.3.3 and 3.3.3.1; Merrill, 1983). This section focuses particularly on the correspondence, and Table 5A.2 portrays the occurrence of CDT-type components in FRAMES, with regard to both *performance components* and *academic content components*.

Table 5A.2 Relationship between FRAMES and CDT

Performance components	
CDT performances	**FRAMES instructional strategies**
Remember	Mode 1 Read-only: provides worked proofs as displays
Use	Mode 2 Guided practice: fill-in-the-blank frameworks
Find	Mode 3 Do it yourself (DIY): mode for independent proofs
Content components	
Types of CDT content	**FRAMES content**
Facts and concepts	Definition components
Procedures	Proof and disproof techniques used in tests for mathematical properties
Principles	Rules for testing whether a relation satisfies various properties and for classifying the kind of relation

To access a component, users select the R of the R A M to call up a relation as the current problem scenario, then the A and M dimensions for attribute (the type of content) and mode (the type of performance) respectively – see Figures 5A.1 and 5A.2 in Section 5A.1.4. There are no fixed combinations of on-screen units. Several components are used simultaneously, so that screens present a windowed appearance, rather than being single-transaction displays. Learners control the selection of components from their *andragogic activity box,* choosing the content, sequence, quantity, the instructional strategy (i.e. mode), and the extent of help they require. Controls are on the right side of the screen; definition of the current relation, visual aids, and supplementary help appear to the left; while content presentation and student interaction occur in a central set of windows.

Whatever the learning style or stage, material would be available to meet the need. For each property, of every relation, in each of the three modes, FRAMES stores both a ready-worked model test for the property - to be used as Mode 1 display components, and partial test-structure components (Modes 2 and 3) to be completed by students as exercises. This forms a rich environment of examples and non-examples. It is unlikely that a single student would tackle every component, but transactions and series of transactions are available, where a transaction comprises a composite RAM selection, for example:

1. Learner-synthesis of ordered pairs that are members of the selected relation;
2. Viewing a graphic aid to form a visual representation of a relation;
3. Viewing or doing exercises, in the form of mathematical proofs, to test whether a relation satisfies a certain property;
4. Doing a series of similar attributes of several relations, i.e. the same property-test on different relations, to consolidate comprehension of that property;
5. Doing several aspects of one relation, i.e. different property-tests on the same relation, to deepen comprehension of that relation;
6. Approaching similar aspects of one relation from multi-perspectives, i.e. the same property of the same relation, in ascending modes. When a practice mode follows directly on a presentation mode, the former remains on-screen and can be used as a model; and
7. Tackling composite integrated analysis of a relation, determining whether it is of a particular kind by testing the relevant set of properties.

In designing according to CDT principles, each proposed component or instructional transaction is positioned by the designer in its appropriate cell on *Merrill's performance-content grid* prior to any implementation (see Figure 3.2 in 3.3.3.1). Viewing the grid identifies gaps in the proposed instruction, helping to ensure adequate coverage and implementation of objectives. Figure 5A.3 categorizes the components of FRAMES on this matrix, indicating excellent coverage of the domain. Certain components (the *read-only* Mode 1, as well as definitions, elaborations, and graphics) are for *perusal*, while others (Modes 2 and 3, as well as example synthesis) elicit *performance* by learners.

Figure 5A.3 Performance-content matrix for the FRAMES components

Level of performance	Fact	Concept	Procedure	Principle
Find			Property - Mode 3	Examples synthesis
Use	Definition blackboard	Help- maths, graphic aid	Property - Mode 2	Help - definitions, Example synthesis; Kind of relation
Remember	Definition blackboard	Graphic aid	Property - Mode 1	Kind of relation

Type of content

5A.2.1.2 Viewpoint of the instructor-designer

The previous section sets out my personal intentions as instructor-designer of FRAMES, explaining the rationale behind its component-based design. There are two further points:

1. As well as incorporating concise *unitary components* for basic knowledge and skills, i.e. the rudiments of the domain, FRAMES has advanced components that present/test complex skills, and it also offers *composite components* which integrate property test components to determine the kind of relation.
2. The property test components have subcomponents, in that they are subdivided into chunks, resulting in a step-by-step appearance of the proof/disproof.

5A.2.1.3 Findings from survey of the learners

The learner-evaluation of FRAMES (De Villiers, 1999b, 2000) focused on its underlying learning theories and characteristics. The findings show how students select instructional transactions in different ways, choosing their own personal set of components, both in terms of content and instructional strategy. They decide on the sequence and quantity of practice, choosing the modes / definitions / elaborations / examples / illustrations / proof-executions appropriate to their individual learning style or stage. Certain *quantitative* questions in the general FRAMES evaluation of 1997 relate to the component-based structure of FRAMES, and responses to these are outlined in Table

5A.1. They investigate students' impressions of using the components and the utility of various kinds of components. Answers to specific survey questions were rated on the five-point scale below, and the average ratings of the 14 participants are shown in Table 5A.3, indicating highly positive impressions. Standard deviation is a measure of dispersion, i.e. it indicates data spread. The low values of standard deviations in Table 5A.3 show closely-clustered ratings.

5 Strongly agree	4 Agree	3 Maybe	2 Disagree	1 Strongly disagree

Table 5A.3
Learner-responses to structured questions relating to components

	Statement	**Average rating**	**Standard deviation**
1	The demo screens are easy to use.	4.28	0.61
2	The demo screens helped me get started, so I knew what to do when I started the RAM exercises.	4.07	0.73
3	When I do RAM exercises, I can easily access the one I want.	4.43	0.65
5	The FRAMES system is easy to operate.	4.07	0.62
6	The blackboard-style definition of the current relation at top left is helpful.	4.43	0.19
8	It is easy to access the HELP information such as definitions and graphic aids.	4.57	0.45
9	The definitions of mathematical properties are a useful form of HELP.	4.64	0.50
10	The attribute called "EG" (for synthesis of ordered pairs) helps me to understand the relation.	3.86	0.67
11	The graphic aids help me get a feel of the relation.	4.07	0.62
14	It is easy to understand the meaning of the icons and symbols in the right-hand quick-control column.	4.07	0.62
15	I got stuck.	2.07	0.83

The high ratings for Questions 3, 6, 8, and 9 show indicate ease of use and the utility of optional support facilities. Ways in which students combined components were described in the *qualitative information* obtained from their elaborations and descriptive comments. Data from open-ended responses in the questionnaire survey and from the in-depth interviews, has been combined. Selected comments follow:

- ***Basic knowledge:***
  I never needed the book. If you don't know at first what something is, then you click on the screen and it expands. / I liked the elaborations of maths symbols, because I was not familiar with them all.
  On the other hand, some learners stated that they did not need elaboration options.

- ***Performance components:***
  I first use mode 1 to understand. / Mode 1 shows you how to do it, then the others prove whether you can. You move on to them because <u>the person behind the computer</u> has shown you how to do it. / For exams you practice with mode 3. /
  I will use those difficult kind-of-relations problems to get confidence before the exam.

- ***Content components used in different ways:***
  Learners varied the type and quantity of their practice, tackling subskills or composite skills; as many as required. Each learner combined components in their personal style:
  I liked that you could take one relation and do so many different tests /
  I liked the examples where you could substitute to see how it really is (note; this learner is referring to synthesis of members of the relation) /
  I choose one relation, starting with its properties then do it all together, analysing the kind /
  I first did one test, e.g. reflexivity, on all the relations till I saw the pattern.

5A.2.1.4 Concluding discussion

The FRAMES components effectively supported learners as they reviewed theory and practiced the skills of the domain. They were able to access a range of content components - ranging from revision of definitions, through reading simple worked examples, to composite integrated problems. Furthermore, they could tackle exercises in different ways, choosing a performance component (mode) appropriate to their learning needs or stage of study. The variety of ways in which different learners combine components was intriguing, and shows clearly how component-based support integrates with customised learning - an aspect which is addressed further in 5A.2.5.

There were no negative comments on these features. Two of the 1997 learners initially perceived the full screens as 'a bit cramped', but soon found the interface easy to operate and use, and benefited from all the information simultaneously available. It must be remembered that these were first-level students, some having their first exposure to computer systems. Another requested that the graphics components be permanently on screen, due to their value. However, they are scaffolding components - students should ultimately be able to solve problems without them, so they are deliberately an optional component.

5A.2.2 Cognitive learning theory

Cognitive learning relates to the promotion of true comprehension, rather than rote learning and conditioned responses. An evaluation of cognitive learning should examine the capability of an instructional intervention or learning event to integrate new knowledge with old; to foster the development of mental schemata; to encourage higher-order thinking skills; and to support learners in self-planning and monitoring (section 2.3.2.1). This section overviews FRAMES in relation to the explicit and implicit incorporation of cognitive learning practices, and also checks FRAMES for use of West *et al*'s cognitive strategies (see 3.3.2.3:2). The aspect of self-regulation, which also relates to customization of learning, is not addressed here, but deferred to Section 5A.2.5.

5A.2.2.1 Initial discussion

It is a requirement of this study that the learning and instructional theories investigated should belong to the cognitive family. Cognitive learning is a key element of the Hexa-C Metamodel, most of the other elements being related to it (De Villiers, 1998).

Integration of new with prior knowledge and formation of schemata

Comprehension of new material occurs in a context of guidance, knowledge structures, and support. For example, Mode 2 provides a content-free problem-solving structure, elaborated in 5A.2.2.3 which visually prompts learners to interrelate theory to the current problem. Also, relationships such as 'if ... then ... ' structures help learners construct internal schemata.

Metacognitive strategies (see 3.3.4.1)

FRAMES includes exercises that promote concept development as learners tackle example-synthesis - a process which lends itself to abstraction and generalization. The mapping techniques explicitly and implicitly incorporated in FRAMES develop general intellectual skills.

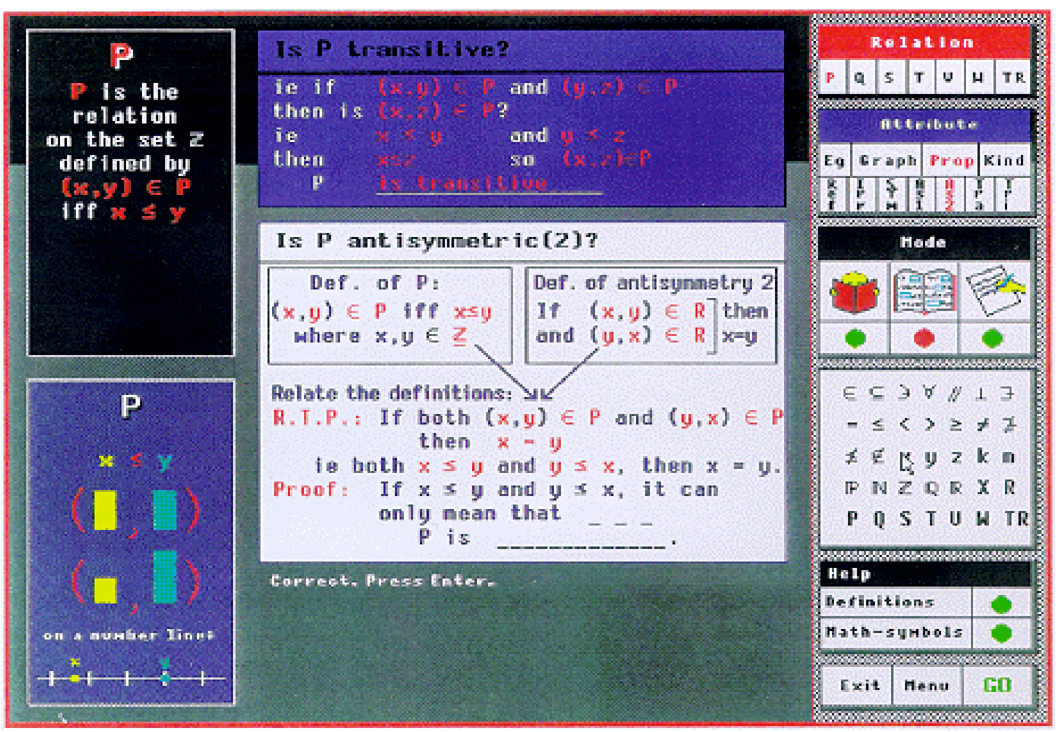
Use of West's cognitive strategies (see 3.3.2.3:2)

1. Chunking - there is rational ordering of chunks. In general there is no underlying sequence of components, because learners choose their own. But within the exercise components used for practice of problem-solving procedures, a template presents the stages in sequence. This mitigates against confusion and cognitive disparity.
2. Concept-mapping - principles are related to specific examples.
3. Rehearsal and multiple presentation - material can be approached and reviewed in various ways - graphically or textually. Within the textual forms, it can be used in three different modes.
4. Graphic imagery - visual representations illustrate the concepts and aid perception.
5. Mnemonics - are incorporated to aid recall and simplify use.

The multiple modes of presentation are clearly indicated in Figure 5A.4, where the learner chose relation **P**, namely $\leq$ (less than or equal to), 'written' on the 'blackboard' at top left, and also selected the **Graphic** component to aid visual perception – see bottom left. The first central proof component is a completed **transitivity property** test in **Mode 3** (DIY) where only a skeleton structure is provided: ' if … then …' and the learner must supply further content. White font represents the fixed structure, and red the learner's contribution, which is entered and judged in chunks. Further colour coding is used for different properties, for example, transitivity tests have a blue background and antisymmetry white.

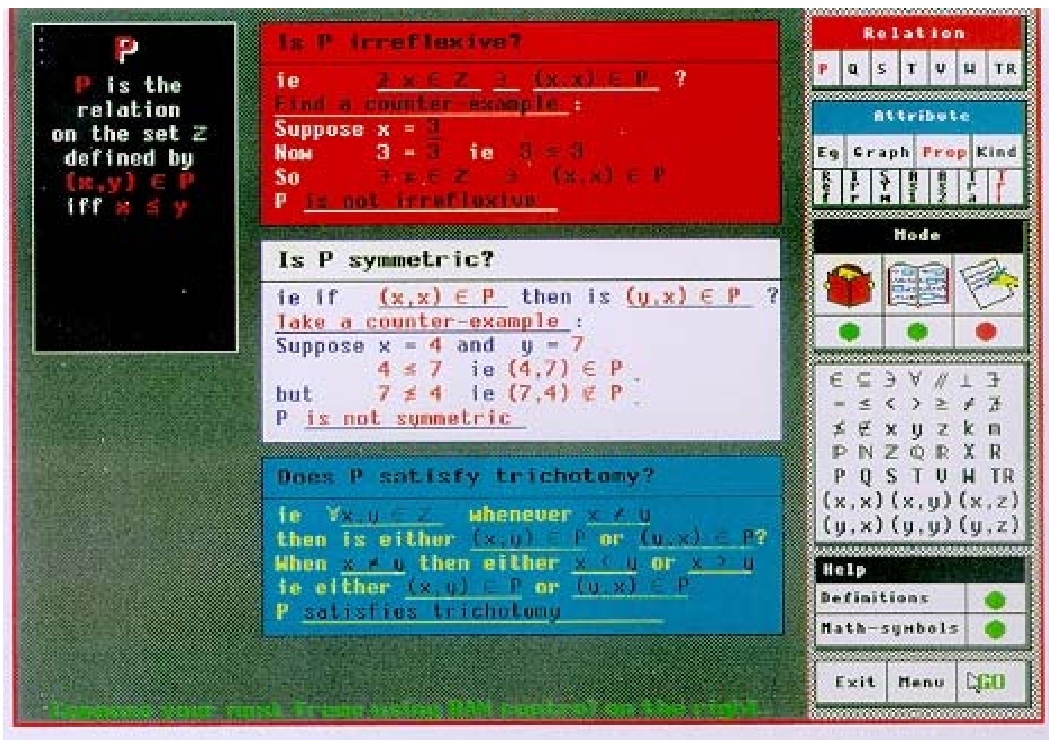
The next central component illustrates the support structures of **Mode 2** (guided practice), presented in an **antisymmetry** test. Arrows link definitions to the proof, visually prompting learners to relate theory to the problem. Mode 2 offers more structure and support than Mode 3. Once again, learner's input appears in red. This proof is incomplete; the feedback underneath is in response to the step most recently entered. The control area on the right offers all the functionality of the main menu, but in reduced form. Note the symbol pad of mathematical characters.

Figure 5A.4 A FRAMES operational screen



When a learner elects to do a property test/s (see **Prop** highlighted in red in the Attribute menu), a lower-level line menu (see the vertical text for abbreviated properties) appears directly beneath the line of top-level attributes. The screen in Figure 5A.5 shows how the learner did three property tests on the relation, **P,** all in **Mode 3**. The red highlighting on the vertical '**Tri**' within the lower-level line menu, represents the current selection of 'trichotomy' in the third central component in the figure. In comparing Figure 5A.5 with Figure 5A.4, it is noted that the learner has chosen to decrease the level of support and is working without the optional visual aid (**Graph**). As previously explained, a step-scroll mechanism builds up the central display area as the student selects instructional transactions, and moves components off when the screen is full.

Figure 5A.5 A FRAMES operational screen



5A.2.2.2 Viewpoint of the instructor-designer

There is no need to add to the discussion above, but I would like to stress the value of explicitly including cognitive features in learning materials over and above the actual subject matter, in order to help learners actively manage their study experiences.

5A.2.2.3 Findings from survey of the learners

Certain questions in the general evaluation of 1997 relate to aspects such as chunking, guided practice and support for self-monitoring. Results are given in Table 5A.4, followed by qualitative data obtained from the substantiation of open-ended questions.

Table 5A.4
Learner-responses to structured questions relating to cognitive learning

	Statement	Average rating	Standard deviation
7	The step-by-step build-up of answers really helps.	4.71	0.21
26	It was useful having the structure of the proof set out in Mode 2 and Mode 3.	4.14	0.73
28	After using the pre-set structures in FRAMES, I will know how to approach written examples in the exams.	3.57	0.94
31	I would use FRAMES in different ways at different stages in my studies.	3.86	0.86

The pre-set structures in Mode 2 guide learners along the ideal solution path, as they test whether the current relation satisfies mathematical properties. The structure does not permit a different sequence within mathematical proofs, although there are correct variations. The responses to Questions 26 and 28 and the open-ended responses below show the value of this guidance, although two learners would have liked to do it in an alternative sequence.

Qualitative data was obtained by integrating responses to the open-ended questions in the 1997 questionnaire survey and information from the 1998 in-depth interviews. The responses indicate that FRAMES facilitates cognition. Selected comments follow:

- ***Integration of new with prior knowledge:***
  I really appreciated the way definitions were built into the proofs. / I first used it to learn definitions, then practiced relationships. / I learned how to define properties, then I could start proofs.
- ***Self-regulation, metacognition, learners planning and monitoring their learning***
  You could plan. I like to choose the order. / It taught me to think analytically. / To solve a problem it makes you think of all the things related to it.
- ***Schemata (representations to show relationships); guidance; and heuristics (rules) to help learners construct internal conceptual schemata:***
  The guidance in mode 2 explains it all. / It taught me to combine concepts. / It helped me to understand the relationship between a relation and its properties.
- ***Chunking - rational ordering, step-by-step, avoiding cognitive overload:***
  The response to question 7 was very positive. Furthermore:
  When you see only one part at a time, you realize what is most important. / Now I know how to start.

- ***Rehearsal and multiple presentation - approaching and reviewing material from different perspectives:***
  For a specific relation, I would first do mode 1 then mode 2 then mode 3. / The visual representation gave me ideas to get to a practical answer.
  (More analysis of modes in 5A.2.5 on Customization)

- ***Cognitive strategies; problem solving techniques****:*
  You keep a proof on the screen to use as a model. Then you do a different one using the pattern. / Teaches you to think analytically and holistically. / You think in the right way, then get it right when you go back to paper. / I like to read mode 1 step-by-step, guessing what comes next.
  (Note: the approach above uses a component in a way not envisaged by the designer, i.e. incorporated subversion - see 2.4.5.3:1.)

- ***Use of certain behaviourist elements (but with a cognitive goal):***
  The repeated entering of the definitions helps with the learning of them and using them in proofs /
  The structure forces me to answer exactly to one solution pattern.

- ***Aspects that could hinder learning:***
  - Questionable colours:
    ... might be a problem to some one who is colour blind, especially where FRAMES gives the right answer (after an incorrect student-answer) *in red characters on a grey background.*
    But another said: *I like the colours very much.*
  - Time-consuming techniques:
    Most learners did not describe problems clicking in math characters from the symbol pad, but two complained: *There should be keyboard shortcuts. / Finding the characters, using both keyboard and mouse restricted my learning. I was too busy finding characters to understand the theory.*
  - More elaborations required:
    There should also be a definition table for some of the new maths symbols.

5A.2.2.4 Concluding discussion

The guidance and support enabled learners to grasp this complex section of work. They were able to reinforce their prior theoretical learning and integrate it with the new problem scenarios. By combining use of the three modes, learners personalised the problem-solving strategies and gained a holistic view - a mental model - of each relation. They learned to integrate all the aspects that must be considered in solving problems. The support-as-needed facility worked well. For learners with little confidence, worked examples (Mode 1) and elaborations were available, whereas advanced learners could focus on using the environment for rapid practice of difficult work, with minimal on-screen objects.

However, the examination of FRAMES showed some minor cognitive shortcomings.

- Learners requested additional elaboration of mathematical symbols.

- FRAMES enforces regular keying in of definitions in Mode 2. This is to prevent students tackling a problem without first considering the theoretical definition of the current relation and the requirements of the current property. It is a form of cognitive conditioning to ensure correct solution paths. However, the process can be tedious, and there should be an option for automated entry of the definitions once the learner is ready. Should such a facility be abused by learners to avoid entering definitions at all, that would be part of the self-monitoring and own-responsibility associated with adult learning.

- There is a trade-off between time-consuming programming techniques and the added value. For example, entering math characters is complex. Doing a proof entails typing in normal words via the keyboard and clicking in special characters from the symbol pad. A frustrated student suggested keyboard shortcuts, but these would cause cognitive load in remembering / looking up the function keys, and would likely be less efficient than mouse-clicking. This student was a professional programmer, accustomed to sophisticated business systems, whereas FRAMES, is an academic aid for a small target group. The same student added: 'Otherwise, well done. As a programmer, I can see the work that went into this'. The same trade-off between programming effort and added value is encountered in the frameworks for Mode 2 proof structures, which use one method only, despite the correct variants.
- To save screen space, abbreviations are used, e.g. 'ref' for the 'reflexivity property'. Two students found these difficult the first time. There should be explanations in supporting documentation or on an introductory screen

5A.2.3 Constructivism

Some of the key features to be considered in an evaluation of constructivism in a learning event (section 2.4.2.1) are: active participation of learners, knowledge construction, authentic contexts, the approach to errors and assessment, and multiple perspectives on the topic. Further aspects of constructivist learning are acknowledgement of real-world complexity and the use of collaborative learning. True constructivism and personal knowledge construction cannot be implemented in a closed, procedural domain such as the mathematical realm of FRAMES, where there is only one correct solution to each problem. However, there is a place for the application of selected constructivist elements. The following subsections set out an investigation of these aspects in FRAMES from the viewpoints of the researcher, designer and learners respectively.

5A.2.3.1 Initial discussion

Learners using FRAMES are helped and guided as they construct their own comprehension of the domain, and internalise the decision-making processes (De Villiers, 1998). Ways in which constructivist aspects are featured/not featured in FRAMES are listed in a table structure:

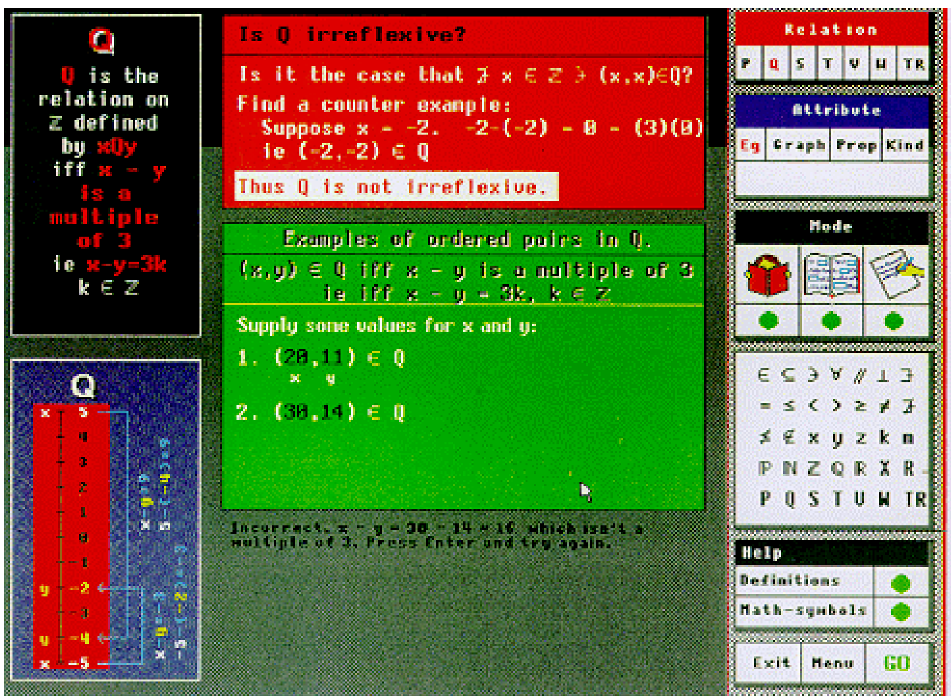
Table 5A.5 Constructivist aspects of FRAMES

Aspect of constructivism	Featured in FRAMES by	Results / comments
High participation by learners in an interactive system	User-control allows students to take the initiative - planning and controlling their practice experience in terms of content, sequence, quantity and instructional style.	The system responds to every action, including feedback geared to the nature of their errors when they are solving problems in Mode 2 or Mode 3.
Anchored instruction	Abstraction is related to reality by providing the full definition of the current relation and optional graphic aids.	Learners begin to get a 'gut-feel' of each relation and start to recognise common patterns and variations.
Real-world relationships	Accurate perception of a problem domain and its examples achieved by the visual aids, but particularly by the opportunity for learners to synthesize their own examples of the current relation.	The system uses its knowledge of the underlying mathematical relationships to test learners' input and provide feedback as to whether they are examples or non-examples.
Contextualized process development	Mode 1 entails step-wise demonstration of mathematical processes. Mode 2 presents a generic problem-solving format where students provide the missing information by keyboard and mouse input. It supplements the proof structure by explicit visual linking of the definition of the current mathematical relation to the definition of the property for which they are testing. Pull-down elaboration and definitions are available during proofs when required.	Learners are exposed to problem-solving techniques within the contexts of specific examples. A drawback is that FRAMES presents one fixed sequence only (a best-practice sequence), and not the alternatives. It does, however, accept synonymous responses within that sequence.
Transfer of skills	The relations in FRAMES expose learners to variety, and the consolidated practice aids retention of principles.	Transfer of skills is facilitated by practice within the environment. A learner who grasps the principles can do different examples in assignments or exams.
Multiple presentation of information	The three instructional modes, read-only, guided practice, and DIY, offer varying perspectives on the process. Graphics supplement textual presentations.	FRAMES supports different learning styles and stages of study.
Approach to errors	Errors are not handled in a constructivist manner, but are identified by judging mechanisms. FRAMES can diagnose some of the common errors and highlight the cause, thereby supporting students in correcting them.	True constructivism tolerates errors and capitalizes on strategic exploration of errors
Integrated testing -	There is no formal testing or scoring. Completing a task successfully is the integrated 'test'.	Learners do not feel threatened, nor is unwarranted optimism raised.

Synthesis by learners of their own examples of the current relation is a valuable form of constructing knowledge. Learners key in examples/non-examples and these are assessed by FRAMES' knowledge of the inherent inter-relationships. Figure 5A.6 shows an attempt to generate ordered pairs that are members of Q, the relation where the difference between the x- and y co-ordinates is a multiple of three. The first pair (20,11) gives a difference of 20 - 11 = 9, which is a multiple of three, and therefore satisfies the relation. The second pair (30,14) is a non-example, as explained by the diagnostic feedback in the small black font beneath.

The top central component is a Mode 1 'read-only' proof. The visual aid at bottom concretizes an abstract relationship; it uses colour coding to relate text to corresponding points on the number line. *Note*: Fonts that are small in the figures are legible when portrayed in full-screen size.

Figure 5A.6 Operational screen showing example synthesis



5A.2.3.2 Viewpoint of the instructor-designer

FRAMES is a learning aid for doing proofs in a computational mathematical discipline. Implementation of constructivist learning in such a domain allows for personal knowledge construction, but not for personal interpretation. Problems do not have open-ended solutions - there may be minor variations on the correct solution path, but there is only one possible solution when testing whether or not a given property holds for a specified relation. Constructivist design, in cases where the fundamental skills of procedural subjects must be taught, offers little scope for open-ended learning or conventional constructivist learning environments, but instead can be applied to offer contextualized support and multiple means of presentation.

5A.2.3.3 Findings from survey of the learners

A few of the questions in the general FRAMES evaluation of 1997 relate to constructivist aspects within FRAMES. The responses to these questions are shown in Table 5A.6, and subsequent discussion, but even more valuable information comes from the qualitative open-ended questions and from the interview respondents.

Table 5A.6
Learner-responses to structured questions relating to constructivism

	Statement	Average rating	Standard deviation
29	It is a waste of time doing interactive practice when I can read worked examples in the tutorial material.	1.29	0.47
30	FRAMES helped me with the more complex proofs in the section of COS101-S on relations.	4.21	0.58
32	I know that FRAMES is intended to be a non-threatening practice environment, nevertheless I would like a scoring facility.	3.21	1.42
33	I should like practice environments for other sections of my studies.	4.71	0.61

The statements in Table 5A.3 measure the extent to which the unfamiliar problem-solving approach in FRAMES supports learning more than conventional text book worked examples and paper-based practice. Responses to 29 and 33 are strongly in favour of interactive practice environments. The standard deviations are low, indicating close clustering of the ratings.

Qualitative information is obtained from substantiations, descriptive, open-ended responses, as well as from comments in the interviews. The learner-evaluations of FRAMES (De Villiers, 1999b, 2000) confirms a constructivist approach, anchored in examples:

- ***Active participation - learners planning and controlling their own learning and practice experience:***
  When you listen to a taught lesson or watch a video, you remember the beginning and the end, but when you are involved in doing it, you can't forget. / Best part was that I could interact. / I try things out.
- ***Anchored instruction and contextualized process development:***
  It's brilliant to see the patterns in mode 2. / After doing proofs <u>I know what the theory means when I open the book again.</u>
  (This learner was using examples to progress inductively to the underlying theory.)

- ***Visualization and graphic aids as multiple perspectives*:**
  Another way to get it into my head. / Diagrams make the concept clearer. / They showed the relationship between the numbers / Written definitions can be so cumbersome. / These aids make it simpler for me.

- ***Real-world relationships - by synthesis of examples and non-examples*:**
  They give me ideas, so I can work out what the right answer will be. / It helps me see which pairs really belong in the relation. / If you key in wrong pairs, computer says it does not ft and you must think why.

- ***Transfer - applying the strategies to more complex problems:***
  When I do different problems, I know how to apply it.

- ***Integrated testing, i.e. no formal testing or scoring:***
  The standard deviation (1.42) in the responses to question 32 indicate varying attitudes, a stance confirmed by learners' comments:
  It never made me feel stupid / Distance-learning is scary enough - please don't threaten us with a score.

  But another said: *I would like a mark, not every time, but when I feel ready,*

  An achievement-oriented individual wanted: *tangible demonstration of prowess*.

5A.2.3.4 Concluding discussion

Considering the closed nature of its mathematical domain, FRAMES succeeded in implementing several constructivist features. How best how can constructivism be implemented in a closed procedural domain? By active participation, self-generation of examples, multiple means of presentation, and supported discovery-learning. As a learner said: 'When you are involved in doing it, you can’t forget'. Also by highlighting the underlying real-world relationships - by transforming an abstract formula into a concrete reality, so that learners personally construct the relationship between the elements of the co-ordinate pairs and perceive its implications. When learners comprehend a relation in this way, they often instinctively know which mathematical properties it will satisfy, and when doing proofs/disproofs, will know in advance what the answer should be

Inductive learning - progressing from practicing examples to conceptual understanding of theory - worked well, and learners attained a conceptual understanding of the underlying principles.

5A.2.4 Collaborative learning

An examination of the collaboration dimension of a learning event must distinguish between collaborative and co-operative learning (Section 2.5.1). True collaborative learning involves teamwork with capitalizes on each member's abilities, sharing authority and responsibility as they work on a shared project. Co-operative work is less flexible and involves joint work by small groups to accomplish a specific goal or develop a specified product. Since FRAMES was designed as a stand-alone CAI system for isolated distance-learners, its evaluation was not intended to investigate collaboration or co-operation. No questions in the 1997 survey were focussed on these aspects, but information from the 1998 interview survey reveals that three of the four interviewees worked *co-operatively* with fellow-students. The next subsections set out the findings and review FRAMES against key elements of co-operative learning (Section 2.5.1.2; Johnson & Johnson, 1991).

5A.2.4.1 Initial discussion

The FRAMES environment is not a virtual classroom, an online course, nor an environment for team-based projects. It makes no explicit provision for open-ended computer-supported collaborative learning or learner-learner communication. It was designed as support for isolated distance-learners, yet students who live in the same locality spontaneously enjoyed joint use (De Villiers, 1999b, 2000), an example of incorporated subversion (see 2.4.5.3:1).

In small-group co-operative learning, students interact to accomplish a specific goal - such as a closed problem with a single solution. FRAMES has been effectively used by pairs of students at a computer, finding joint problem solving satisfactory and stimulating. This type of learning is often used a means of achieving mastery in foundational knowledge (Section 2.5.1.1; Panitz, 1996), but in the case of FRAMES, also enriched the learning of more complex, integrated skills. Listed in Table 5A.7 are some of the features that show sound co-operative use in FRAMES.

Table 5A.7 Co-operative learning in FRAMES

Key elements	Featured in FRAMES by
Shared goals	Activities selected by learner-consensus (no activity involved product generation);
Positive interdependence	Students gained confidence and made progress as a result of joint decision-making and peer-teaching.
Individual accountability	Only self-accountability - FRAMES is a personal learning aid.
Social negotiation	FRAMES is characterized by choices - selecting which activity to do / deciding on what text/characters to enter in problem-solving. Learners negotiated regarding their input.
Sharing and support *(promotive interaction)*	Breaking down the isolationist characteristics of distance-learning. The learners who used FRAMES effectively developed positive attitudes and were enthusiastic about sharing their new discovery.

5A.2.4.2 Viewpoint of the instructor-designer

Since FRAMES was envisioned as a supplementary aid for isolated distance-learners, it was a pleasant surprise when students spontaneously mentioned how they had benefited from using it co-operatively. The learners who used FRAMES in this unanticipated way seemed even more excited and enthusiastic about the learning experience.

5A.2.4.3 Findings from survey of the learners

No survey questions were formulated regarding co-operative learning, since joint use had not been envisaged. However, information elicited from telephone conversations indicated that several of the participants in the 1997 survey were working jointly. Furthermore, three of the four in the 1998 interview survey (De Villiers, 1999b, 2000), revealed that they liked to work two-at-a-computer, finding that co-operative problem-solving led to enrichment and better performance. There is therefore qualitative information, but no quantitative data:

- ***Discussion and negotiation*:**
  We have different ideas and they collide, then we go together to the computer and it explains. /
  It really helps to work together /
  I don't have to wait until I can contact a lecturer. We discuss it together and work it out.

- ***Interdependence and improved performance:***
  At the beginning he understood more and he helped me. But now I can do it better!

- ***Sharing and support:***
  It helped me - now I want to show my friend on the computer.

5A.2.4.4 Concluding discussion

FRAMES achieved a purpose beyond its explicit goals. As a computer system, its interface was intended for single users, not joint usage. The kind of co-operation that occurred goes beyond anthropometric issues, moving into the territory of simple human needs and social requirements. Learners experienced satisfaction and boosted confidence by sharing their learning experiences - in fact, one student brought his learning-partner along to the interview. Moreover, two brains were better than one for difficult activities. Designers should take cognizance of the fact that, for many learners, collaboration and communication are inherent aspects of learning.

5A.2.5 Customization and learner-centricity

Evaluating customization of learning and learner-centricity (Section 2.5.2) in a learning event involves determining the extent to which individual learners' interests and requirements are met. Learner-centredness views learners holistically, considering both their cognitive and affective interpretations, and changing the instructor's role more to that of a facilitator. Reigeluth (1997) highlights customization as the most important feature distinguishing instruction and learning in the Information Age. This section investigates the implementation of cognitive customization in FRAMES, whereby learners themselves contribute to customizing an event to their needs.

5A.2.5.1 Initial discussion

FRAMES is not an artificial intelligence system that offers intelligent student modelling, but it is an environment characterized by adaptability, individualization and high interactivity. It supports individual learners in customizing the system to provide the material they personally require. They control their own progress though the FRAMES components, selecting their learning activities - both in terms of content and type of performance - and can also decide whether or not to use the support options - definitions, elaborations, and graphic representations. To distance-learners, unaccustomed to individual attention, the environment offers personalized support (De Villiers, 1998). Table 5A.8 sets out some of the explicit ways that learners are supported personally by FRAMES:

Table 5A.8 Customized learning in FRAMES

Aspect of customized learning	Feature in FRAMES	Implications / comments
Response-judging and feedback when solving problems in Modes 2 and 3, and in example synthesis	Response-judging is a major processing event in FRAMES, as learners' input is assessed. Feedback is designed to identify likely errors.	Provision is made for two attempts at each answer-entry point. For correct answers, alternatives and spelling variations are acceptable. Several versions are on hand at each answer-entry point.
Explanations and help .	Elaborations of mathematical symbols are available when required. Optional help facilities are accessible as on-line pop-up definitions and rules.	This quick-and-easy extra support is useful in early learning stages, or for learners who lack confidence.
Flexible approach; Learner-control in choice of content, mode, and quantity	FRAMES has a rich environment of varied components, so that individual learners can spend the amount of time they choose and do the quantity of work they wish - picking-and-choosing components in any sequence. Some activities entail perusal; others elicit performance.	True learner-centricity is implemented by the absence of : (i) pre-set paths through practice material, and (ii) fixed screen combinations.
Instructor in role of	The environment was designed for	Learners use it for independent practice

facilitator	isolated distance-learners.	of skills.

5A.2.5.2 Viewpoint of the instructor-designer

It was interesting to find out how students used FRAMES to suit their own learning needs and style. Their responses in the sections on components and cognitive learning, as well as those in 5A.2.5.3 in this section, indicate a wide variety of usage patterns.

5A.2.5.3 Findings from survey of the learners

Some of the structured questions in the general FRAMES evaluation of 1997 relate to ways in which learners control their learning and how FRAMES is customized to their needs. Table 5A.9 shows the responses.

Table 5A.9
Learner-responses to structured questions relating to customized learning

	Statement	**Average rating**	**Standard deviation**
16	I appreciate the learner-control that lets me do what I want, as much as I want and in the way of my choice.	4.36	0.84
17	The feedback was useful.	3.5	1.02
18	I learned to use FRAMES quickly.	4.5	0.52
24	I prefer doing exercises on paper.	2.86	1.35
25	I find it difficult to use the RAM access method.	1.64	0.91
31	I would use FRAMES in different ways at different stages in my studies.	3.95	0.86

The responses to Question 17, relating to feedback, are less positive and more varied than others (standard deviation = 1.02). Although diagnostic feedback is attempted, it falls short of being intelligent feedback, since the software program compares learner-answers to certain stored versions, comprising correct responses as well as common errors. If the learner's answer does not fit one of these patterns, there is no diagnostic feedback. Responses were varied with respect to Question 24 on preferred methods of working. FRAMES made it possible to do mathematical exercises via a keyboard-mouse combination, but it is somewhat cumbersome, an aspect already discussed in 5A.2.2 on cognitive learning. The responses to the other questions show that FRAMES is easy to operate, and that the freedom offered by learner-control has high utility.

In qualitative open-ended responses and in answering interview questions (De Villiers, 1999b, 2000), students describe how they controlled the environment and customized it individually:

- ***User-control for efficient learning, as students select components appropriate to their learning style and stage of study*:**
  I could choose what to do, as well as the order! /
  I'm very systematic, so I did them all. I tried out everything, even different answers, to see if they were also right. / Much better than video - a video can't answer you back like FRAMES does.

- ***Response-judging and feedback to learners' steps in problem-solving processes*:**
  When I get an answer from the computer, I remember it / When it corrects you, then it proves where you are wrong and says "No guys, this is the way you do it."

  The response-judging mechanism is designed to diagnose common errors (as in the case above), but cannot diagnose all possible errors. Four learners stated that they would like to know exactly what was wrong with every answer, and where they started to go wrong:
  You are not sure which part is wrong and will most likely go wrong the second time.

  The patterns against which learner's efforts are matched have an in-built sequence for each step. Some, but not all, alternatives are recognised. Students' views on this differed:
  You could improve the syntax checking, so that where order is not important, it does not mark it wrong. / Although I might have a different approach, it is good that it forces me to answer with the best approach. / It's a bit harsh to have to write the answer in a rigid format, but OK - I suppose it's good to learn the best way.

  FRAMES has no editing facilities. To correct a step, it must be completely re-entered:
  It was good for me to re-do the whole thing for consolidation. /
  It was irritating having to do the whole part again.

- ***Multiple presentation of information*:**
  As shown in Table 5A.5, each of the three modes was chosen by four students as the one from which they learned most. Some appreciated a certain mode at a particular stage of study. FRAMES thus supports different learning styles, and also the differing needs of the same learner at different times,
  e.g. *I use Mode 1 as a model for doing assignments and Mode 3 for practicing before the exam.*

Table 5A.10
Use of the three modes

Statement	Mode 1 No of students	Mode 2 No of students	Mode 3 No of students
20 Mode I enjoy the most	6	7	1
21 Mode that helps me learn the most	4	4	4
23 Mode I like least	2		9

5A.2.5.4 Concluding discussion

Learners appreciated the way FRAMES met their individual needs. From the pre-set content, they could choose activities customized to their learning style and requirements, and they could use the environment in different ways at different stages of study. The utility of each of the three modes was confirmed by the fact that each was, for an equal number of students, the one from which they learned most - in spite of the fact that nine did not actually like Mode 3. They found a variety of ways of combining exercises and modes that resulted in individualization, leading to consolidation of theory and skill acquisition.

Normally, in a closed, structured domain, there would be little emphasis on a learning experience meeting learners' specific interests, since there are no open-ended topics to explore. However, FRAMES did meet some learners' customized interests. As a CAI environment, it matched the interests of Computer Science students. One young, enthusiastic learner remarked, 'I am studying to be a computer programmer and hope one day I could write a program as fantastic as this'.

The system's responses to students and their ability to control the activities they chose, made it seem so 'human' that some of them personified FRAMES with comments like 'it answers you' and 'it says'. The quantitative and the qualitative data indicate certain inadequacies in the response-judging, feedback and re-entry of steps, yet in general learners were very satisfied with the personal tutoring, such as the student who stated that ' ... it proves where you are wrong and says "No guys, this is the way you do it" '.

FRAMES is learner-centered in supporting cognitive processing (see this section and 5A.2.2 on cognitive learning) and in meeting affective needs (see 5A.2.6). There is a strong inter-relationship of customization with creativity and motivation in learning, the aspects overviewed in the upcoming Section 5A.2.6 .

5A.2.6 Creativity

An evaluation of creativity and motivation (2.5.3.1 and 3.5.3) should look for innovative and novel features, while ascertaining that such features do not impact on functionality. Aspects to be considered are:

- The extent to which instruction motivates and engages learners;
- flexibility in instructional strategies;
- how information is presented; and
- the kinds of activities.

A further matter to investigate is recognition of the complexity of the cognitive-affective connection, and what features are incorporated to promote sound values, positive attitudes, and hard work.

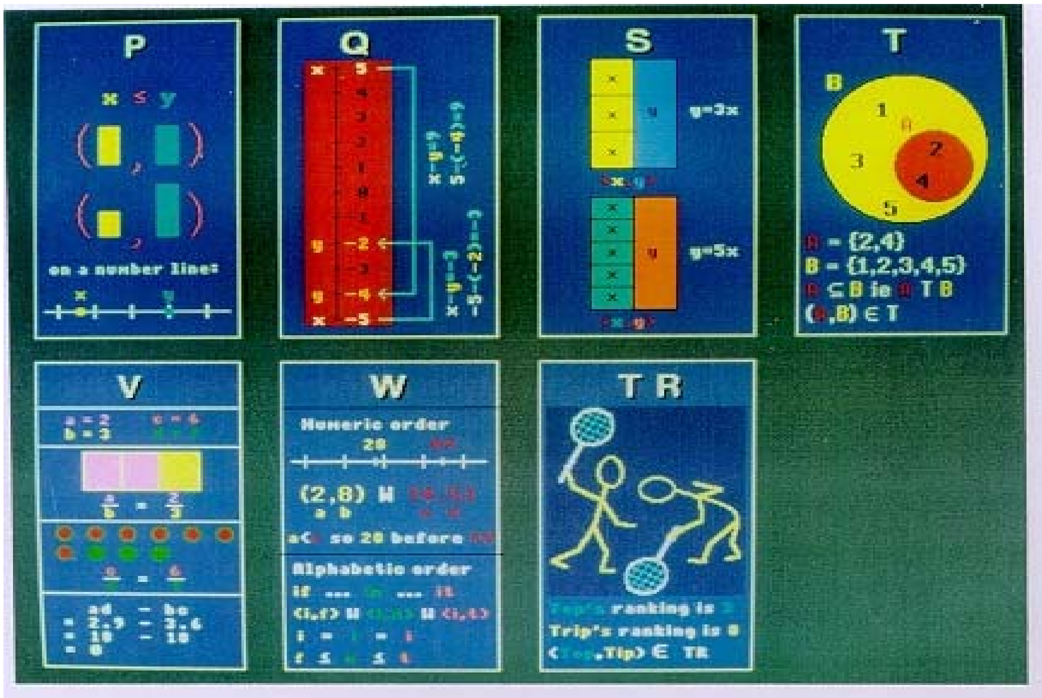
These aspects are incorporated in the evaluation described in this section, as well as a brief inquiry into the application of Keller's (1987) ARCS model in FRAMES.

5A.2.6.1 Initial discussion

FRAMES is a novel and highly interactive environment. It entailed innovative instructional strategies and complex computer-programming techniques (De Villiers, 1998), developed through experimentation and prototyping. The design requirements were imprecise, requiring trial and testing. Screen layouts evolved in a form-follows-function manner, rather than adhering to specifications or storyboards. Figures 5A.2 and 5A.4 show the consistent screen layout for functional areas such as control buttons (right) and the definition *blackboard* and graphic aid (left). As learners select instructional transactions, they generate screen displays comprising their own personal set of components. The selected exercises appear in the center, as has been illustrated in the preceding figures, and the step-scrolling mechanism moves them off-screen when the area below fills up with subsequent components. Mathematical symbols are clicked in from the symbol pad in the right hand functional area. All these features are novelties, differing considerably from previous CAI systems developed at Unisa.

Each relation is illustrated by an optional colour-coded graphic aid. Visualization facilitates perception, application, and retention, and enlivens up the screen. The metaphors were carefully designed to represent the mathematical and real-world relationships. Figure 5A.7 is not a FRAMES screen display; it was compiled by combining all the graphic aids for the purpose of demonstration.

Figure 5A.7 The graphic aid components



FRAMES engrosses learners and induces anticipation. Learners gain satisfaction by organizing their learning experiences, and gain self-confidence as their performances improve. There are no bells-and-whistles, such as themes or rewards. Some learners were so engrossed that they experienced *flow* (see 2.5.3.1; Czsikszentmihalyi, 1990) and *lost track of time* (Wager, 1998), occurrences that are described by learners in 5A.2.6.3.

5A.2.6.2 Viewpoint of the instructor-designer

The *virtual table top* is an original approach, in which the screen layout and user interface provide the facilities and objects that typically lie on students' tables as reference materials when they do exercises. For example, definitions would be available on a real table (probably in an open textbook), worked examples are frequently used as models, and diagrams are used to aid comprehension.

The wide variety of built-in options for doing exercises - simple or composite, a well as the opportunity to synthesize ordered pairs and test whether they belong to the relation, all done with varied levels of support, make FRAMES an *androgogic activity box* of options. Screenshots in the preceding figures indicate how learners can simultaneously view graphs, definitions, and other worked examples, while they tackle their current activity.

5A.2.6.3 Findings from survey of the learners

Questions in the general FRAMES evaluation of 1997 were not directly focussed on creativity. A few are indirectly relevant and are shown in Table 5A.11. Two relate to the 'demo', - the demonstration component, a simple exercise that students use to learn the system.

Table 5A.11
Learner-responses to structured questions relating to creativity

	Statement	Average rating	Standard deviation
1	The demo screens are easy to use.	4.28	0.61
2	The demo screens helped me get started, so I knew what to do when I started the RAM exercises.	4.07	0.73
33	I should like similar practice environments for other sections of my studies.	4.71	0.61

The most useful piece of information in the table is the highly positive response to Question 33 - the highest average rating in the whole survey - indicating students' desire for more software like FRAMES. More informative comments came from the qualitative data in response to open-ended questions and the interviews (De Villiers, 1999b, 2000):

- ***Matching learners' specific interests***
  Computer Science students really appreciated CAI:
  When I work on computer I never think about time. / The computer draws me - it's a better way. / I never knew you could do educational things on the computer - it's amazing!

- ***Motivational strategies, Keller's (1987) ARCS model involving***:
  - **Gaining and holding <u>a</u>ttention:**
    Entertaining - could do it all day! / Absolutely brilliant / It was easy. I never got cross with it. / The nicest way I've ever learned. / Loved it. / I could not get off the computer. / and best of all: *Excellent – I even forgot I was learning;*

  - **Demonstrating <u>r</u>elevance:**
    Shows all the important things, so you don't waste time / Good for Unisa students, because it tells you immediately, you don't wait for the next day to phone a lecturer

  - **Instilling <u>c</u>onfidence:**
    Now I know why to do things that way. / I can go it alone / I'm positively clear about things I used to think were difficult;

  - **Providing learner-<u>s</u>atisfaction:**
    Learners tackled varied activities with a positive attitude:
    Typing examples was the best way to see if you understand. / If you get it wrong you must think why.

- ***Intrinsic motivation generated by high interactivity:***
  After a session I feel I must sit down and master the next section. /
  I want to work more. / I could not get off the computer.

- ***Some aspects were irritating:***
  The interface and introductory screens irritated some learners: *Tedious and un-user friendly. /*
  After the first time I would like to bypass the intro screens.

- ***Novel and innovative ways of practicing:***
  Personal interaction / Chance for experimentation / Guidance /
  I had seen the concepts in the book, but when I saw them being used, then I understood. / Synthesizing examples was a chance to see if you really understand - if you key in wrong pairs, computer says it does not fit and you must think why .

- ***The virtual table top:***
  Everything was there, I never needed the book. /
  You must read the book first, then you can put it away, because you have all you need. /
  FRAMES gives the main concepts concisely /
  Having all the info on the screen is a big plus.

5A.2.6.4 Concluding discussion

Some were surprised to enjoy academic work! The comments show that they not only benefited, but also had a good time with their *activity box*: 'I was learning and I was practicing and I was enjoying myself!'. They had not encountered anything similar, and were intrinsically motivated and engaged.

With regard to the instructional strategies and activities, FRAMES is more about learning than about instruction. The primary learning strategies are active participation, and wide variation in activities - opportunities to 'try things out'. Certain students were so engrossed that they found it hard to stop! The way the information is presented makes it simple to use. Two described feeling daunted by the extent of the prototype environment, then being surprised how easily they grasped the system.

Shortcomings were identified relating to the interface and introductory screens, aspects that are not cumbersome to change, and that should be rectified.

Finally, there is the issue of the cognitive-affective connection, and incorporation of features to promote sound values, positive attitudes, and hard work. FRAMES' primary strategy here is high interactivity and experimentation. Learners enjoyed using FRAMES - the affective element was as strong as the cognitive. High motivation induced a desire to work more than they had intended, and resulted in effective learning.

5A.3 General

This section proposes how the five facets of a learning environment are made up in FRAMES and also briefly mentions the use of computer technology in FRAMES.

5A.3.1 Facets of the FRAMES learning environment

Table 5.A.7 shows the Perkins' (1991a; Section 3.5.4) five facets of learning environments, and the ways they are implemented in FRAMES and its wider learning domain.

Table 5A.12 Facets comprising the FRAMES practice environment
(Perkins, 1992)

Facets that comprise a learning environment	Corresponding implementation in FRAMES
Information banks (external to FRAMES)	Textbook Study guide Tutorial letters
Symbol pads	Computer (at home, at work, or in Unisa lab) Rough notes
Construction kits	FRAMES interactive practice facilities
Phenomenaria	Help components, definitions, visual aid and example-synthesis components within the FRAMES environment
Task managers	CAI aspects of FRAMES Individual learner Cooperative partner

5A.3.2 Technology in FRAMES

Technology is central in FRAMES, since it is a computer-based interactive practice environment. The environment served as an effective medium of presentation and interaction, with learners' attention focused on the message and not on the medium. Certain minor frustrations were expressed (Section 5A.2.2.4), but in general the medium was transparent, and several comments indicated that learners perceived the virtual presence of a human teacher.

5A.4 Conclusion to the FRAMES evaluation

This evaluation of the interactive learning and practice environment, FRAMES by a volunteer sample of Unisa students indicates that the user-controlled, component-based system operates as the designer had envisaged, yet in a richer manner, as some learners found unanticipated applications. The investigation of FRAMES using the Hexa-C Metamodel as an evaluation tool, shows features in line with all six elements of the framework, despite the fact that FRAMES is not the archetypal domain where elements such as constructivism and collaboration would usually be implemented. The investigation also revealed various design shortcomings.

Integration of elements

The examination was focussed on the learning event, but also provided information regarding the elements of the tool itself, indicating strong interrelationships between its elements. Appropriate to its role as a supplementary aid for practice of procedural skills, FRAMES is a strongly component-based system. Its activities and instructional transactions induce high interactivity and ongoing cognitive processing. Constructivism is implemented to a considerable degree, despite the closed, well-defined domain, and in fact, the constructivist goal of supporting personal knowledge construction in a mathematical realm contributed to the creativity of the design. Constructivism is also implemented in the spontaneous co-operative use as learners find socially-negotiated understanding. Learners personalize FRAMES in different ways appropriate for their individual needs or stage of study. The cognitive-affective connection highlights the integration of the elements of the metamodel under the umbrella of cognitive learning; this is addressed further in Chapter Six.

Triangulation

For interest's sake, the examination marks of the eighteen learners who evaluated FRAMES were investigated. The average mark that the fourteen learners in the 1997 survey obtained for the question on complex relations was 9% higher than the general average. The results of the four 1998 learners who were interviewed on their use of FRAMES were even better - they averaged 31% more than the general average in the relevant section.

Instructional design of the system

Section 5A demonstrates that the FRAMES instructional design succeeded in its purpose and aim (see Table 5.1). The simulated table top achieved its objective, as did the concept of pick-and-choose from the andragogic activity box. Comments indicate the presence of phantom - a virtual coach - 'the person behind the computer' who 'has shown you how to do it' (5A.2.1.3) and who suggests 'No guys, this is how to do it!' (5A.2.5.3). An interviewee, referring to its novelty and value, said 'I wish I had something like it for all my modules, because I am a person who learns by examples'.

A problem in COS101 is that students typically tackle a problem concentrating on what is **required** - aiming for premature conclusions, instead of deriving conclusions from the **given information** and then aiming for the goal. One of FRAMES' most valuable contributions is its problem-solving template, which enforces integration of theory, the given scenario, and practice. This guidance was shown to facilitate learning.

Incorporated subversion

Most activities had been anticipated by the designer, but others were positive subversion. The qualitative research method uncovered several such occurrences in FRAMES:

- Spontaneous co-operative use;
- Use of the chunking in Mode 1 in a 'guess what comes next' fashion; and
- Using a Mode 1 read-only presentation of a proof in a particular relation as a model for Mode 2 or Mode 3 problem-solving, but using a **different** relation to increase the cognitive gap and hence the challenge. (This strategy had been anticipated but within the context of the **same** relation.)

Extensions and refinements

FRAMES is a prototype in terms of its content. All the functionality is there, but some further relations must be added. In the process, some concerns and technical irritations can be rectified, such as the lengthy introductory sequence which always offers the demo option, and the lack of a quick-exit facility. Two minor editorial errors, identified by four students, were corrected immediately. Certain other shortcomings would be difficult to rectify in a cost-effective manner, so those changes may not be implemented, due to the trade-off between programming effort and added value.

Finally ...

FRAMES has been shown to be a rich learning environment, supporting the current paradigm shift towards flexible instructional software. Its high levels of interactivity and individualization capitalize on the capabilities of the computer, customizing the environment to the needs of individual learners. Students were engaged by its innovative, cognitive strategies, and appreciated having control of their learning experience, supported by a comprehensive virtual table-top. Interactive practice, (sometimes in pairs), accompanied by instant feedback, enriched studies and led to personal construction of content, followed by retention and transfer. Learners themselves conclude the discussion of this case:

> *As a distance education student, I can't ask questions, but with FRAMES I can;*
> *The part of my studies I enjoyed most;*
> *A useful tool - a good combination;*
> *This is good interactive software.*
> *I could try things out – the things I wonder about . . . and I learned so much.*

Section 5B - *Case Study Two: RBO880*

The second case study relates to RBO880, an Internet-based course that teaches educators about the use of the Internet in instruction and learning. The Hexa-C Metamodel is applied to evaluate RBO from the perspective of learning theory, and to examine whether and how it achieved its design aims.

In the first part of Section 5B, RBO, its context, content, and learners are described. The next and major part of the section is devoted to discussion, evaluating the course according to the six 'C' elements - learning theories and characteristics - that comprise the framework of the HCMm. Each section is further divided into three perspectives:

(iv) Initial discussion by the *researcher*;
(v) viewpoint of the *designer* of the learning event (who is the course instructor/facilitator);
(vi) *learner-data* - quantitative, but mainly qualitative, obtained from surveys and interviews;

before ending with a *concluding discussion*.

In all aspects of education and training, there is increasing use of electronic learning applications, including the Internet and World Wide Web. As virtual learning environments and web-based instruction increase, online material proliferates - much of it bypassing scrutiny. Internet-based resources should meet the criteria of accuracy, authority, currency and uniqueness (Smith, 1997). It is also necessary to maintain quality in terms of the instructional approach (De Villiers, 1999a). In the vital applications of online instruction and learning, it is essential that the academic content, underlying instructional and learning theories, and the implementation paradigms, all three, be such that instruction is effective and cognitive learning is enhanced.

The structure of Section 5B, which describes an investigation into RBO, is identical to that of Section 5A.

5B.1 Introduction to RBO880

5B.1.1 Immediate domain and purpose

RBO880, generally called RBO, is a one-semester masters-level module in Computer-Assisted Communication and Management at the University of Pretoria, with the abbreviated course title, Internet-based Learning. It is one of nine modules for the MEd degree in Computer-Integrated Education (CIE) offered by the university's Faculty of Education, but can also be taken as a short course for non-degree purposes by learners with an appropriate background. The whole course is presented online on the Internet, i.e. it is *immersive* with relation to Harmon and Jones' (1999) five levels of web use, as it uses its website to set out course information and communicates via an e-mail forum. RBO can be viewed as an electronic, or web-based, simulation of a physical classroom. Its general aim (Cronje, 2001b) is to develop in its students the theoretical and practical expertise to use computer-mediated communication via the Internet as a tool for presenting, managing and facilitating resource-based learning and distance education. Course topics are *Learning on the Internet* and *Management of network-based teaching - academic and administrative*.

RBO students do practical task-based projects, as well as written analytic and interpretive assignments. The semester work comprises individual tasks, co-operative small-group tasks and a major whole-group collaborative project involving multi-media. There are no tests or conventional examinations; instead, the exam is a major individual project worth 50% of the final mark. Learners post all their products on web pages and also provide links to the collaborative and co-operative projects in which they had a part.

The particular aim of RBO is for the educator-cum-learners who take the course to experience first-hand the situation of Internet-based learners. Not only do they gain the required theoretical knowledge and practical skills, but they do so in a position which gives them empathy with their own learners and enriches them as consultants in computer-integrated education.

The RBO topics and tasks described in this study are those presented during 2000, although mention is made of tasks and events in previous presentations.

5B.1.2 Greater environment and learners

The University of Pretoria is a contact-teaching institution in the capital city of South Africa; it has over 27 000 students. The university has taken an active role in telematic teaching and 51 of its academic programmes are currently presented/supplemented online as part of a model of flexible learning, using a mix of media-, web-, contact- and paper-based teaching. RBO is not a directly a part of this telematic teaching initiative, and the MEd (CAE) degree, for which it is a credit, is a contact degree. However, due to RBO's nature as a course in computer-assisted communication and management, it is itself presented online using facilities of the World Wide Web and Internet. The instructor calls it *Teaching 'teaching on the Internet' on the Internet* (Cronjé & Clarke, 1999). There are no meetings or fixed class times. Students tackle the course asynchronously in the place of their own choice, but are expected to adhere to deadlines for task submission. The core information and instructions are provided on the RBO website, but supplemented with regular communication, as students daily access their newsgroup facility to receive messages from the instructor and communicate with fellow-learners. Online chat sessions are also scheduled. Instructor and learners provide their personal e-mail addresses, so that one-to-one messages can be sent when required. Learners not only find information on the WWW, but generate their own web pages as part of individual and collaborative projects.

Class size is approximately ten students annually. In general, the students are mature adult learners, employed full-time, with ages ranging from 30 - 50, doing post graduate studies in education for enrichment and to gain further skills - typical life-long learners. A few are younger students who continue directly to masters-level after completing honours degrees. Most of the RBO class are MEd students, but some are professionals in similar fields doing the course for non-degree purposes as enrichment.

5B.1.3 Roles: the RBO880 developer, instructor/facilitator, and the researcher

The current lecturer is a professor who has presented RBO since 1995. He developed the current distance-presentation version of the course in 1997 and designed its website, i.e. the roles of instructional designer and educator converged. Furthermore, design was not separated from the implementation of instruction, since the lecturer in his role of instructor-designer could refine the approach iteratively in the light of previous experience, and even implement minor refinements to instruction, schedules and content on an immediate basis, if and when required.

The researcher took RBO for non-degree purposes as an external student in 2000 as a learner in a class, initially, of eleven. She was, therefore a learner-observer-evaluator. In this study, she evaluates the content, tasks, and examination of the 2000 presentation from the perspective of learning and instructional theory, using the elements of the HCMm as a framework. She undertook qualitative analysis by surveying 22 students (13 who completed RBO in 1999 and 9 of the class of 2000), so that the learner-evaluation incorporates a broader base than just the researcher's fellow-learners in 2000.

5B.1.4 The approach, classroom, and tasks in RBO's electronic world

Text Box 5B explains the approach of RBO, in particular its metaphorical classroom and the objects in the classroom.

Text Box 5B The virtual world of an RBO learner

The RBO electronic classroom (Cronjé, 1997; Cronjé and Clarke, 1999) uses the metaphor of a junior school classroom. Branscomb (1996) points out how 'Metaphors serve as a map for sorting out what is similar and what is different when confronting a new problem'. In the web-based classroom, the instructor-designer set out to mimic, in a web-environment, the objects and events of a real, physical classroom. For Jones (1997, cited in Cronjé 2001b), 'the degree to which information technologies can effectively control or aid virtual communities is delimited by the finite capacity of human cognition ... Humans can think about almost anything, but they cannot deal with everything at once'. Because of this, the visual similarity between the digital classroom and its real-world counterpart must be as strong as possible since the physical differences are great. The students do not communicate face-to-face, nor do they meet at all.

The classroom has two components - a website and an electronic mailing list. The website represents the physical aspects of a classroom and the list server allows the interpersonal (speaking) interaction and communication that occurs in a class situation. The classroom and its associated mailing list comprise a 'virtual settlement' (Jones, 1997 cited in Cronjé 2001b).

The web-based classroom

The 2000 web-classroom, which resides at the URL <*http://hagar.up.ac.za/rbo/2000/index.htm*>, is shown and discussed in Figure 5B.1 following this text box. It has four sections:

1. At the top of the screen are buttons which link to the virtual documentation of the course - matters such as the required outcomes, tasks, timetable, references, etc. Clicking on these provides details of the associated timetable (see Figure 5B.4), tasks and so on, similar to information on notice boards or in printed material in real classrooms. (Some of these objects are elaborated in the discussion following Figure 5B.1.)

2. The second major object is the poster wall, which links to projects by previous students, as well as links to any 'posters' created by the students as the course progressed.

3. On the right is a blackboard, implemented as a graphics file. As a special challenge, students may access and edit this 'chalkboard', manipulating it and replacing it, amounting to the graffiti on a blackboard in a real classroom. Technologically, this is a reasonably complicated task, but several rise to the occasion.

4. The most important area, from the learners' perspective, is the central region containing their 'desks'. Each student's desk links to the personal website he/she develops in the course of the module. Students replace the initial generic desk image in the classroom website with an abbreviated personalized desk representation. This representation is linked by a URL to the full-scale 'desk' or even a 'study', designed by the learner in their personal website.

The idea is for the learners progressively to 'fill their desk' with objects typically associated with a school desk, namely their:

- Ears (mail to: ... their e-mail address as contact information, in lieu of direct conversation);
- Utility bag (links to utilities such as HTML editors, search engines, clipart libraries);
- Textbooks (links to useful sites);
- Work (relevant work they do/did in their studies/employment);
- Hobbies (personal info and links to sites of special interest);
- Class work (RBO assignments and tasks); and
- Portfolio (a link to their examination project).

Electronic communication

The initial electronic presentations lacked real-time interaction; this was introduced in the class of 2000 by holding two synchronous sessions using a 'Chat' facility. General conversation and communication with the instructor is done by means of a dedicated mailing list. The message acts conducted in the classroom are similar to conversations in a face-to-face classroom. The messages sent through this class discussion list (Cronjé and Clarke, 1999) indicate that the most frequent actions of the instructor are to make suggestions, give information, explain how to do something, offer encouragement, and give directives. Learners mainly use the communication forum to provide information, ask questions, present a problem, generally initiate/contribute-to discussion, or to express amusement or a joke. As the course matured, the communication broadened to include discussion and suggestions regarding collaborative tasks, as well as issues of confrontation and conflict.

The classroom is also augmented with 'extra lessons' by means of a link to an HTML tutorial.

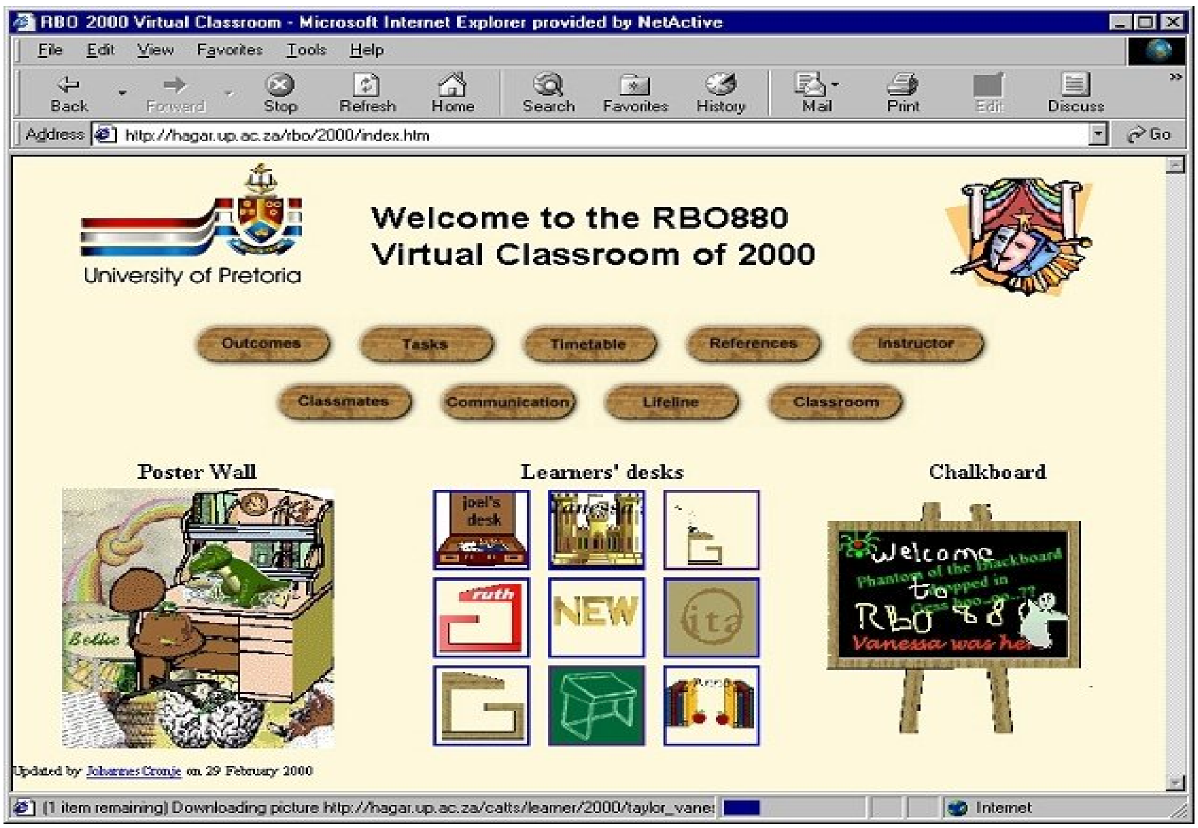
Class behaviour

The personalized desks and the inter-learner communication show an interesting blend of students' creativity or lack of it – much the same as one would find in a real classroom. Certain students respond to the metaphor by 'down-aging' and role-play. They take on the roles of learners in a schoolroom, addressing the instructor as 'Sir' or 'Teacher' in their emails to the mailing list. Such learners tell tales on one another, interrupt proceedings with humour, and generally act with a light-hearted air. They exercise typical schoolroom mischief, for example, by using their desk to represent 'bunking class'. When this spontaneous role-play activity occurs, it assists in developing a team spirit.

Other characteristics of a class are conflict, 'bullying', and criticism of fellow-learners. These too, occur from time to time in the RBO communication.

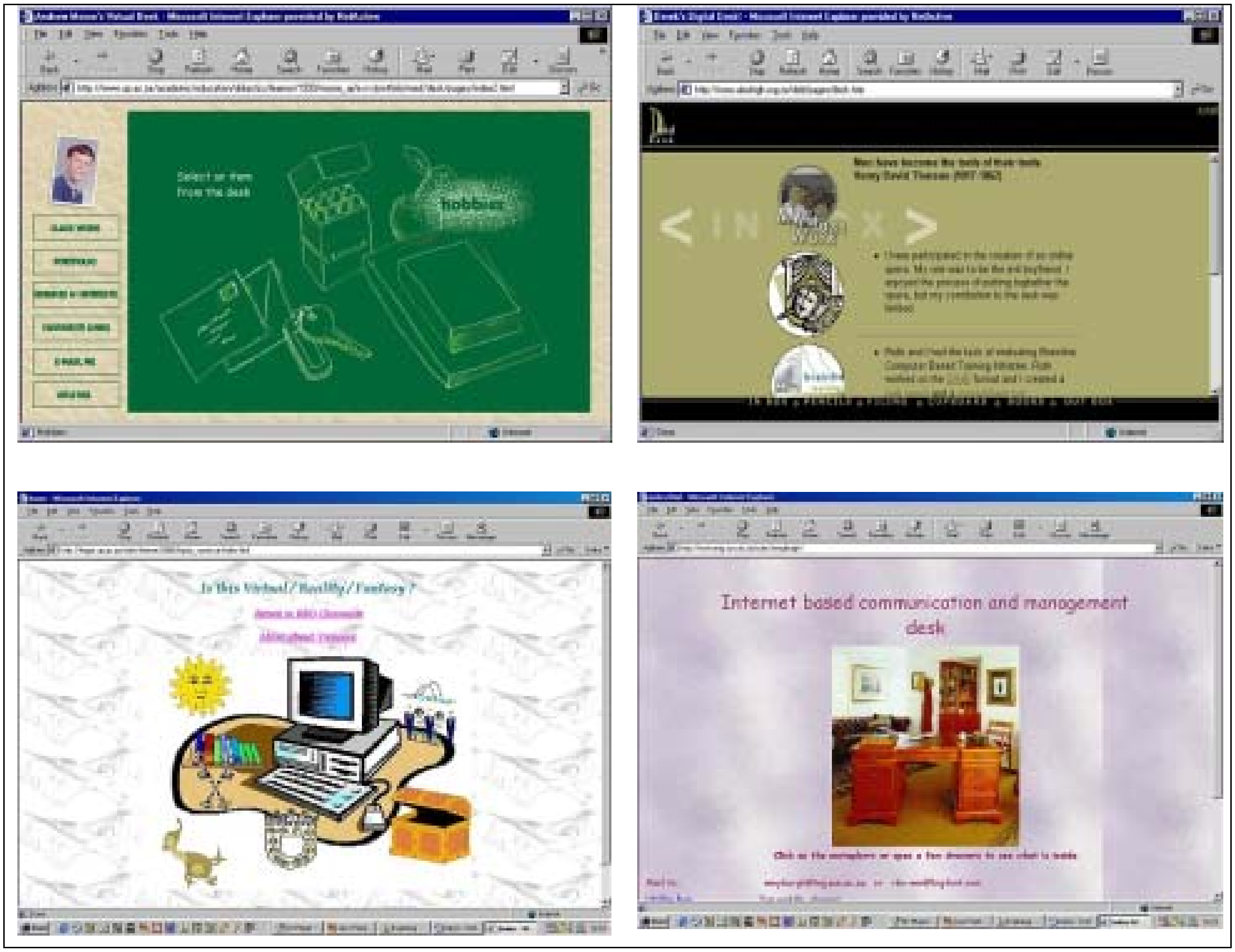
Figure 5B.1 presents the website of the class of 2000, showing the 'classroom' described in the text box. Several attributes of a physical classroom are simulated. The buttons at the top link to objects such the instructor's desk, resource cupboard, tasks and timetable. The instructor's desk branches to his home page containing links to aspects of general interest. The references (comprising resource cupboard and tool box) entail links to subject matter and construction programs such as hypertext mark-up language (HTML) editors, as well as additional reference information, graphics utilities, and website construction tools. Clicking on others accesses academic information, such as the course timetable and tasks, required outcomes, topics to be covered, the grading system, and the practical competencies learners should acquire.

Figure 5B.1 Website of the RBO electronic classroom



The objects and material within, and accessible from, the classroom increase as the course proceeds. The learners' mini-desk representations (centre screen in Figure 5B.1) link to each learner's full-scale desk on his/her own home page. Figure 5B.2 shows four different full desks created by learners in 2000.

Figure 5B.2 Desks of four of the learners of 2000



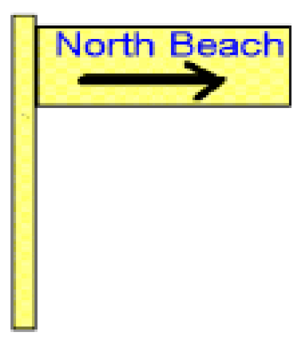
Each desk communicates something of its owner - formality/informality, personal characteristics, web-skills, and so on. Clicking on the objects on and around the desks links the viewer to the objects bulleted in Text Box 5B. Each learner has a personal set of such objects.

Exercise for the reader:

Try to match each desk in Figure 5B.2 with its linked mini-desk in Figure 5B.1.

The mini-desks are also revealing. The class of 2000 was fairly conventional, but previous students used humour to convey messages, as shown in the mini-desks in Figure 5B.3, where the former communicates a learner 'bunking class' (i.e. playing truant/ 'hookie').

Figure 5B.3 Mini-desks of two former learners



After constructing their desks in the first two weeks, the class of 2000 tackled the collaborative opera, then the two-person team tasks, as shown in the timetable in Figure 5B.4. Finally, the individual projects, which comprised 50% of the final mark, had to be completed over a six-week period.

Figure 5B.4 The RBO timetable for 2000 (RBO880, 2000)

Phase	Date	Purpose	Activity & Deadline [Time = SA Standard time (GMT + 2)]
Pre Intro	Sat 5 Feb	Familiarisation	Students enrol on listserver; browse in virtual classroom.
Intro	Mon 7 Feb	Introduction	Students introduce themselves and get to know one another by their *Whoami* postings. All students must have done so by **16:00 on Tues 6 Feb 2000.**
Desks	Wed 9 Feb - Wed 16 Feb	Getting ready	**Individuals** arrange their desks.
Tech	Wed 16 Feb to Fri 3 March	Opera	Students discuss the opera project, identify roles and compose their parts.
Explore	Tue 7 Mar to Sun 19 Mar	Distance Learning and the Internet	Students do their Team Tasks. Final product must be posted to the desks on **Sunday 19 March at 16:00.**
Proposal	Thu 16 Mar to Thu 23 Mar	Proposals	All students must post their project proposals before **16:00 on Thurs 23.** Discussion of the proposals will continue up to **Tues 28 March.**
Kickoff	Fri 23 Mar	Launch project	Students launch their individual projects. These will run for six weeks, i.e. till about **Tues 16 May**. This allows enough time to process data and create the portfolio.
Publish	Tues 4 May	Publish results	The report on the individual project is published on the Web in the form of a portfolio. Deadline **30 May** 16:00 SA standard time.

5B.1.5 Research design of the RBO case study

Within the overall approach of *action research*, as outlined in Chapter One, Sections 1.7.4 and 1.7.5, a combination of qualitative and quantitative research methods is used.

The descriptive data in the six 'Initial discussion' subsections: 5B.2.1.1, 5B.2.2.1, 5B.2.3.1, 5B.2.4.1, 5B.2.5.1, and 5B.2.6.1, is generated by *qualitative analytical research*, investigating the case through an analysis of RBO course artefacts - namely the course website, and listserver. Furthermore, the researcher used a *qualitative ethnographic approach,* obtaining rich observational data by participating in RBO as a learner. Under each element of the HCMm, attention is also paid to aspects of the course that are in line with theories, practices and stances described in Chapters Two and Three.

The information in the six 'Viewpoint of the instructor-designer' subsections: 5B.2.1.2, 5B.2.2.2, 5B.2.3.2, 5B.2.4.2, 5B.2.5.2, and 5B.2.6.2, is obtained by a *qualitative ethnographic method*, interviewing the lecturer for his insight and in-depth understanding of the situation in which he operated.

The primary data collection method for the six 'Findings from survey of learners' subsections: 5B.2.1.3, 5B.2.2.3, 5B.2.3.3, 5B.2.4.3, 5B.2.5.3, and 5B.2.6.3, was a *non-experimental survey* (comprising *questionnaires, 'virtual' observation* and *interviews*). The entire learner populations of 1999 and 2000 - thirteen students in 1999 and nine in 2000, i.e. 22 in total - were used in this evaluation, investigating RBO from the perspective of learning theory. All the questions (except for some Yes/No responses) required qualitative textual answers, i.e. there were no multiple choice questions as in the FRAMES evaluations. The questionnaire, as a whole, is given in Appendix B, but pertinent questions are also inserted in the text. The data in Section 5B is not statistically analyzed, since this would not be the best way to deal with rich descriptive data. Percentages are not determined, because they would not be significant in the case of such a small population. Table 5B.1 shows profiles of the learners surveyed.

Table 5B:1 Profiles of the learner population surveyed
(n = 22)

Characteristic	**Subdivision**			
Gender	Female 13		Male 9	
Full-time / part-time	Full-time 2		Part-time 20	
Prior qualifications	Honours degrees 16		Masters / Doctorates 6	
Ethnicity	White 21	Black 1	Coloured 0	Asian 0

5B.2 Investigating RBO880 using the Hexa-C Metamodel

RBO is investigated with respect to its application of learning and instructional theory, using the Hexa-C Metamodel as a framework and structuring the analysis according its elements. In the analysis that follows, the six Cs of the HCMm are structured into a sequence that addresses, first, the three sections that relate more to the underlying theories and basis of RBO, and then three aspects relating to the more practical characteristics of the learning experience.

5B.2.1 Cognitive learning theory

An evaluation of cognitive learning should examine the capability of an instructional intervention or learning experience to integrate new knowledge with old; to develop skills for storage and retrieval of information; to encourage use of higher-order thinking skills; and to support learners in planning, self-monitoring and transfer of learning. It should also look at the types of learning in the domain.

5B.2.1.1 Initial discussion

This section examines the application of cognitive learning theory and practice within RBO, also investigating the cognitive-affective relationship (Tennyson & Nielsen, 1998), and the application of enterprise schemas (Gagné & Merrill, 1990).

- ***Objectivist-cognitive aspects: entry-level requirements and intended outcomes***

  Entry behaviours: Admission prerequisites are very basic:
  - Possession of an honours or other fourth-level degree,
  - access to the Internet,
  - the ability to upload and download documents to and from the WWW,
  - familiarity with the term *constructivism,* and
  - teaching/learning experience and knowledge of classical writings in education.

  Pre-specified outcomes (specific and critical outcomes) for each task:

  The outcomes relate to practical Internet- and web-competencies, as well as a critical-conceptual grasp of the domain.

- ***Integration of new with prior knowledge***

  RBO learners are a heterogeneous group, with a wide range in prior knowledge and skills. Most are educational practitioners; others are recent graduates, familiar with educational structures from the learner's perspective. RBO learners build on their existing educational skills and experiences, and apply new media to the presentation, delivery and/or administration of their known practices. Some approach the course with prior learning in their own domains, but with no prior Internet skills. RBO does not explicitly teach these, although the website has links to external sites with HTML tutorials, web-construction tools, etc. Implications of this are elaborated under the upcoming header on the *cognitive-affective connection*.

- ***Cognitive strategies***
  RBO uses some of West, Farner and Wolff's (1991) cognitive strategies, in particular, advance organisers and metaphors. Advance organisers on the RBO web pages for *Outcomes* and *Tasks* make it clear what is expected. The conventional classroom metaphor and analogy have been described and illustrated in Section 5B.1.4, showing how the 'desks' are positioned in rows in a metaphorical class space, with further graphics of a blackboard and posters on the walls. In line with the analogy of associating each desk with its occupant, learners auto-customize their desks and hyperlink them to their websites, which expand during the course as they update them with the material listed in Text Box 5B.

- ***Skills for encoding, storing, and retrieval of information or skills***
  Once the initial Internet skills are obtained, they are reinforced by practice. In the course of the various tasks, learners repeatedly use web authoring systems, graphics tools, etc. and upload products to their websites. These skills are consolidated and internalised by frequent use.

- ***Types and categories of learning***
  With regard to the learning types in Bloom's taxonomy (section 2.3.2.2; Bloom 1956), RBO incorporates application, analysis, synthesis, and evaluation. The course calls for some of Gagné's categories of learning (section 2.2.3.1; Gagné & Glaser, 1987), namely, discriminatory and problem-solving skills, and metacognitive strategies as learners plan and control their creative processes. Motor skills are required for proficient use of computer keyboard and mouse.

- ***Transfer***
  The Internet expertise acquired in RBO has been applied and adapted in varied domains and contexts by learners in their own tasks as educators. For example, a university computer science lecturer presented a fourth-level Internet-based course in computer operating systems using a detective metaphor. Another former student ran a course in research psychology, in which students created web pages around specific themes. The instructor provides links to these 'spinoffs' from his so-called 'museum' web page.

- ***The cognitive- affective connection***
  Thinking and learning are complex, dynamic, non-linear processes, making learning outcomes hard to predict. The final outcomes of RBO vary greatly from one learner to another (Cronjé

2001a). Tennyson & Nielsen (1998) apply complexity theory to learning theory to determine the influence of non-linear learning on the design of instruction. Some of the factors that create non-linear conditions are time, anxiety, and environmental variables:

- *Time and personal factors*

RBO learners are part time students, balancing careers, studies, and family commitments. Those who are educators/trainers experience periods of peak pressure during which their own studies cannot be a priority.

- *Anxiety and frustration*

This is a major issue for those who are not competent in web design (Cronjé, 2001a). There is a wide skills-gap in entry-level expertise - some are experienced web educators and web designers; others have only the minimum technical prerequisites, and become frustrated and stressed as they self-construct certain facets of knowledge. These affective issues impact on cognitive processes. Complexity theory proposes interaction of content knowledge and cognitive strategies to help with problem solving, decision making and creativity. RBO addresses this by encouraging learners to form collaborative online support systems, to call on RBO's buddy system which uses past learners as a 'lifeline' (see *Lifeline* button in Figure 5B.1), and to explore the hyperlinks to a range of resources. Students who persevere and use these facilities are able to reach appropriate levels in HTML, graphics, and general web-authoring.

- *Attrition*

Some RBO learners find the situation beyond them. They withdraw, either to re-register the following year knowing what is expected, or to find an alternative course for the necessary credit.

- ***Enterprise schemas for multiple objectives***

Enterprise schemas relate to situations where the instructional goal is a combination of several different objectives (sections 2.3.2.3 & 3.3.3.3; Gagné & Merrill, 1990). RBO integrates multiple objectives in its comprehensive activities. For example, the task on *Distance learning and the Internet,* done in co-operative pairs, involved a comprehensive investigation of an existing web-based teaching initiative. The objectives were to:

- Determine criteria for successful web-based teaching, using the literature,
- Ascertain the aims, procedures, etc of the web-initiative under investigation,
- Analyse the initiative in the light of the criteria,
- Write a report in the format of an accredited journal,
- Submit recommendations to the authorities at the given initiative,
- Develop an interactive spreadsheet to measure WBT-readiness of an organization, and to
- Apply the spreadsheet instrument by using it to analyze the given organization.

5B.2.1.2 Viewpoint of the instructor-designer

> With regard to the level of prior learning and the extent of the work, I think I may have asked too much, too soon, contributing to the attrition rate. Some of the learners in 2000 were scared off by the extent of the initial collaborative virtual opera.

5B.2.1.3 Findings from survey of the learners

Twenty-two students from the classes of 1999 and 2000 participated in an evaluation of their RBO online learning, focussing on its underlying learning theories and characteristics. The questionnaire is in Appendix B, but certain questions relate to core features of cognition, such as the integration of new and prior learning, self-regulation of one's learning experience, and cognitive-affective issues:

7.	Had you used the Internet and WWW in teaching/learning before doing RBO?
8.	With the RBO course behind you, do you classify yourself as a newbie or a webbie?
33.1	Describe how the knowledge and skills required in RBO related to your own prior learning.
33.2	Where you lacked prior knowledge, how did you bridge the gap?
33.3	RBO students largely plan their own study and learning experiences. How does this work for you in terms of scheduling and monitoring your time, other priorities and obligations, self-discipline, etc?
29.4	Did you at any time experience overload and/or anxiety? Please elaborate.

Learner-responses to Questions 7 and 8 indicate low initial skills. Tables 5B.2 and 5B.3 indicate that thirteen of the twenty-two had used the WWW previously, but only seven had created web pages. By the end of the course, seventeen were confident of their web-ability; three still saw themselves as 'newbies', and two did not respond.

Table 5B.2 Internet familiarity prior to RBO			
Had you previously used the Internet or WWW in teaching or learning?	**No of learners (n = 22)**		
Yes	13	To create web pages	7
		For searches only	6
No	9		

Table 5B.3 Internet familiarity after RBO	
With RBO behind you, how do you classify yourself?	**No of learners (n = 22)**
A webbie (proficient)	17
Still a newbie (unfamiliar)	3

Responses to Questions 33.1 and 33.2 about the relationship of prior learning to the RBO skills showed that several entered RBO with a theoretical orientation stronger than their practical competencies. There was a range in entry-level expertise. Some had strong technical abilities, and the (virtual) presence of these expert web-designers resulted in a major skills-difference. Students' comments are categorized below.

- ***Integration of prior knowledge and experience*** (Question 33.1)*:*
  I have a need to discuss and debate /
  Conceptual knowledge of the Web / primitive HTML coding /
  No Internet skills / no web expertise /
  Certain computer and other technical skills, but basically I just kept at it ... /
  I grew up with computer technology ../
  I'm a computer person, not an educator
  Conventional educational expertise - I'm an educator / adult learning /
  Some had a dual foundation:
  Combining my learning theory and knowledge of a web-authoring tool was very relevant.

- ***Bridging the web-skills learning gap*** (Question 33.2):
  I asked, I experimented a lot. / Used the recommended references for the course / Research /
  Studied HTML manuals / Web-searches / Examined the work in previous virtual classrooms /
  Copied others' techniques / Desperation, self-discovery / Networking and asking people who knew how /
  Perseverance, trial and error on the technical things / Reading, reading, reading ... /
  By yelling for help and using RBO's 'lifeline helper' system.
  (Note: lifeline - a buddy system using past-learners as peer-helpers)

The next aspect of cognition (Question 33.3) relates to progression of the work. Most learners did not have problems with the schedule, although some experienced pressure and found that RBO impacted on other obligations.

- ***Self-regulation of the learning process - planning, scheduling and monitoring***
  Hectic!!! / The isolated learning in RBO impacted adversely on my self-discipline. /
  I can't understand why there are deadlines in a course is not class-based - can't it be self-paced?

  Self-regulation plays a critical role in collaborative work:
  The whole group must co-operate, otherwise it delays things /
  My preferred style is autonomy and at the end of the day, I am responsible for my successes and failures. When time constraints undermine the process, I accept this ... It is harder to do this in group-work when the importance of the group-goal needs to take precedence. This is sometimes stressful for me, as I have a strong sense of not wanting to let the side down. In some groups this is not a shared view, and can make meeting the group-goals not very evenly spread among members. /
  I really appreciated fellow students' tolerance when my illness delayed a group project.

Question 33.4 addresses the related field of affective aspects; learners' elaborations are consolidated in Table 5B.4.

Table 5B.4 **Aspects of overload/anxiety**	**No of students** **(n = 22)**
I experienced overload/anxiety	8
Pace was too fast / initial skills-gap	5
Fitting it in with other commitments / Impact on my other studies	7
Meeting deadlines is stressful	3
Technical aspects - making it work	3

Collaboration brings an added dimension to affective issues. Some students take their responsibilities to fellow-learners so seriously that they over-commit. Some under-contribute, but with little impact on overall performance, because others bear the brunt. The comments that follow relate specifically to collaborative work:

- ***Affective-cognitive connection within collaborative work***

  In the very beginning it was overwhelming. The first month was sink or swim - all the initial setting up and then straight into the Opera (note: the Opera was the whole-group collaborative project). *That was probably why the drop-out rate was high in the first few weeks. Then the pace slackened. Those who dropped out will probably be sorry they did not push through that initial difficult month. /*

  I was irritated when someone didn't send through what they were supposed to.

5B.2.1.4 Concluding discussion

RBO exacts a high degree of independent work, and is suited to mature self-motivated learners. It incorporates a broad variety of types of learning - conceptual and practical. Once web-skills are in place, learners reinforce them by the continued development and uploading of web-product. The integration of graphics, animation, text and spreadsheets provides broad exposure to web-design, over and above the educational aspects. The evaluative skills used in the investigation of an existing web-learning initiative and in commenting on fellow-learners' project proposals, hone learners' analytical skills.

The learning environment and requirements are cognitively challenging, but are in line with Squires' (1999) notion of cognitive authenticity (see 2.4.5.3:1).

The evaluation does, however, reveal some cognitive shortcomings. Learners' comments show that RBO makes stressful demands on those with an inadequate technical background, as they struggle to bridge the web-skills learning gap. They also work much slower as they develop their web-based products. A possible solution is to enforce technical expertise as a pre-requisite. Learners without appropriate skills could attend one of Pretoria's University's web-authoring certificate courses, where the practical skills can be acquired in a class situation. Although collaboration brought rich expertise to tasks, it hindered progress and some learners found it intrusive.

The attrition rate is high. The 22 survey participants do not represent the initial complete groups of 1999 and 2000 learners. The 13 learner-evaluators from the class of 1999 represent 13 of the original 22 who registered, i.e. the attrition rate was 9 out of 22. Of the 9 learner-evaluators of 2000, two who completed the questionnaire did not finish the course, so the overall attrition rate was 4 out of 11.

5B.2.2 Constructivism

Key features to be considered in an evaluation of constructivism in a learning event are active participation and learner-ownership, knowledge construction, real-world contexts, the approach to errors and evaluation of learners, and multiple perspectives on the topic. Further aspects are acknowledgement of real-world complexity and the use of collaborative learning. RBO's open-ended tasks lend themselves to implementation of the constructivist approach. The following subsections investigate these issues and also review the foundations of RBO's grounded design (Hannafin *et al*, 1997), as well as comparing RBO with Hannafin *et al's* (1994) open-ended learning environments.

5B.2.2.1 Initial discussion

This section discusses the researcher-learner's impressions of the theory and practice of constructivism within RBO.

- ***Active participation, knowledge construction, and learner-ownership***

  RBO learners actively explore web tools, sites, and facilities, as they build products for their own websites. The end results vary from accomplished professional-type designs to basic text-on-the-web, as learners personalise their desk - using graphics, gimmicks, grandiosity, or just-the-basics. Each mini-desk on the RBO home-page is linked to the learner's full desk and portrays something of the desk's occupant, for example, the feet-on-the-desk and the signpost-to-the-beach, shown in Figure 5A.3. The full desks, in turn, provide links to that learner's information and tasks. To a large degree, RBO learners decide for themselves on the content of their tasks.

  In RBO, domain knowledge is not viewed as a defined set of facts and techniques to be remembered, but as resources to support learners in operating as expert practitioners. This approach necessitates top-down, just-in-time learning, where learners supplement their knowledge and skills, as needed, during the learning-and-construction process. In two of the tasks, RBO supplements personal knowledge construction with socially negotiated learning to provide complementary strengths and support weaker learners.

- ***Instructional goals and learning objectives***

  Figure 5B.5 shows the requirements for two tasks, as given on the RBO web site. First, it lists the outcomes of the whole-group collaborative task, where the students were required to construct a web-based opera. The *modus operandi* is described, but the roles of each learner, how to allocate roles, and the name, content and structure of the opera are not specified. (Note: The group used an analogy, and called their opera, *Phantom of the Internet*. The broad story line and 'songs' were based on themes and tunes from the Lloyd-Webber production, *Phantom of the Opera*).

For the individual task (the examination project) there were two broad options. Within these options, goals were negotiated and projects open-ended - one relating to administration of Internet-based learning, and the other entailing research into facilitating learning on the Internet. The second part of Figure 5B.5 shows the broad specifications for the latter option, indicating the content- and context-independent nature of the exam project.

Figure 5B.5 Outcomes and requirements of two RBO activities
(RBO880, 2000)

Outcomes of the collaborative task

Upon delivery of this product, you should be able to

- Work together as a team.
- Produce web-pages in a frames environment.
- Obtain and produce suitable graphics and animated objects in gif or jpg format and use them to enhance your web page.
- Edit MIDI files and insert them as background objects in web pages.

Present at least 20 Internet terms with their definitions in a decontextualized format.

Requirements of the examination project

Identify a specific context where the Internet could be used to facilitate learning. Design a sustainable project which will ensure that the Internet is used for at least six weeks on a weekly basis. Post your proposal to the listserv for comment from the rest of the group. After incorporating any valid comments/suggestions from the group, run this project and publish a collection of web pages on your results. The publication should be in the form of a portfolio which contains the following sections:

- Rationale for your project
- Literature review
- Description of project and execution
- Findings (data)
- Conclusions and recommendations

- ***Personal learning goals***

Figure 5B.5 shows that RBO content and performance goals are not precisely pre-specified. Requirements are flexible and tasks open-ended, with solutions dependent on the interpretations of the individual or group, resulting in a variety of different objectives.

Learners' personal goals were negotiated, as they posted their exam project proposals on the listserver for discussion. Each chose a subfield of the domain, ideally with personal relevance (so that the product has practical real world value), and used the rich environment of the Internet and WWW to extract, present, and solicit information. The completed artefacts differ radically in purpose, scope, and structure. Examples of projects generated by the class of 2000 are:

- Post graduate didactics of history,
- interactive web-based assessment, and
- industrial skills training on an intranet for semi-literate labourers.

- ***Problem-based / Authentic real-world context***

  Both options for the examination project were real-world problems which learners could relate to their professional situations. The idea was to generate products suitable for use as a learning environment or an administrative toolset in authentic settings of teaching or training. Several students ran their projects on their own learners or invited colleagues to peer-evaluate. The projects were authentic and complex as the learners tackled real-world problems – exploring, correcting, and refining solutions. Note that they were **not simulations of real-world issues, but actual problems** from the work environments or personal contexts of these adult learners.

  Section 3.4.4.2 describes constructivist learning environments (Jonassen, 1999), showing how the problem is the focus of the environment, surrounded by support systems and resources. The **problem drives the learning**, rather than merely serving as an example of concepts and principles. Similarly in RBO, students learn domain content in order to solve the problem, rather then solving problems as application of learning.

- ***Incorporated subversion and exploration of errors***

  Exploration and self-expression are synergistic features well suited to an environment designed for incorporated subversion (Squires, 1999 - see 2.4.5.3). The RBO task that required learners to design their own desk was subverted positively, as students took the basic structures provided and transformed them, configuring them to express individuality. Some of them subverted the graphic to such an extent that there was no resemblance whatever to a desk, as demonstrated in Figure 5B.2. In generating web-artefacts, learners extended and refined their products, and self-corrected errors.

- ***Evaluation of learners and integrated assessment***

  Learners are graded - in line with university policy. The instructor applies multimodality in assessment, evaluating a portfolio of products, as well as participation in online communication, resulting in a form of integrated assessment. Learners submit self-assessment estimations; and although there is no formal peer-evaluation, they can express opinions about the extent and worth of others' contributions. Assessment is not criterion-referenced.

- ***Grounded design in RBO***

  For a learning system to be based on a grounded design (Hannafin et al, 1997; Sections 3.1 & 3.4.3.3), five foundations must be aligned to maximize coincidence and shared functions. The RBO environment is examined with respect to these five:

1. *Psychological foundation*

RBO situates cognition in the development of visible, yet virtual, products related to real objects and events. Individual and shared cognition are focussed on the dual aims of
   (i) assimilating, creating, and collating material, and
   (ii) presenting it in the form of web pages.

Knowledge and skills are applied in ways that add value to real, complex circumstances. All RBO learning is contextualized and elements are not isolated in order to teach them. Knowledge gained is immediately activated in authentic activities, i.e. students learn domain content in order to solve a problem or participate in executing a task.

2. *Andragogical approach*

The andragogical foundations are consistent with the above, since learning and instruction are anchored in realistic, holistic contexts, without simplification or compartmentalization of knowledge and skills. Scaffolding is provided in the form of reading assignments, references to resources, and links to online tools. The instructor provides no coaching, but learning in the 2000 class was facilitated by two 'lifeline helpers', former students who answered queries and guided strugglers and stragglers.

3. *Technological foundation*

Course content and domain heuristics are integrated into the learning tasks and interpreted by learners on a need-to-know basis. Technology is therefore not used as a tutor, but rather offers tools for exploring resources and integrating knowledge in the problem-solving process. This is in line with the constructivist use of technology to promote learning instead of to deliver instruction. The course is not technology-independent, since it relates integrally to learning via technology and is presented on the Internet. But it is independent of any specific web-based platform, training product, software package, or authoring tool/language.

4. *Cultural considerations*

There are various cultural considerations:

- *The organisational culture and systems of the University of Pretoria*
  There are institutional principles and procedures - in particular, the commitment to outcomes-based education (OBE), and a grading structure for the purpose of credits and merit. Hence the entry requirements, specification of intended outcomes, unit standards for each section, time schedules, and mark allocation (50% to pass; 75% for a distinction).
- *The MEd culture for those learners who are part of the MEd (CIE) degree -*
  A culture of mutual support, collaboration, and group projects.
- *Internet culture -*
  A culture of the global community - entailing shared use as hyperlinks permit easy import of material and as underlying code is lifted and modified. Furthermore, it is a culture of saying-it-like-it-is, which can lead to virtual relationships of conflict or even romance.
- *The traditional classroom culture of competition*
  Competitive learners strive to out-perform one another in the products they generate. RBO is transparent in that co-learners' emerging products are exposed on the web for all

to see. An achievement-oriented individual knows exactly what he/she must beat. The transparency includes web-classrooms of previous years, building up a heritage of available ideas and underlying code.

- *Finally, the 2000 presentation had an inherent Eurocentric flavour*
  This was due to Opera project with its Western theatre structures. This could be a disadvantage to learners of African origin, unfamiliar with classical opera.

5. *Pragmatic foundation*
   Hannafin *et al* (1997) suggest pragmatic accommodation and balanced foundations to mitigate against extreme constructivism. RBO remains highly constructivist, but also has objectivist features in the prespecification of its (very general) objectives, unit standards, and outcomes. It is distinguished from many conventional courses in that products developed by learners must have a practical application.

- ***RBO as an open-ended learning environment (OELE)***

OELEs (Hannafin *et al,* 1994) empower individuals to learn, rather than promoting mastery of specific concepts. They support student-centric learning, with parallel application of technology and are associated with constructivism and situated cognition. Three of their critical assumptions (see 3.4.4.3) are reflected in RBO:

1. *The process and the context of learning are closely related.*
   RBO embeds learning in experience and in authentic contexts. The resources it offers form a type of online phenomenarium, in which learners can create virtual products. The rich environment of the Web can provide multiple perspectives and multiple approaches toward solving a problem.
2. *The cultivation of cognitive processes can be more important than actually generating learning products*. The decision-making, interpretation of data, and self-reflection inherent in RBO activities help learners develop higher-order thinking skills and invoke metacognitive skills.
3. Finally, *the qualitatively different learning processes of OELEs require qualitatively different methods*. RBO's examination project incorporates problem-solving, theory-building, and hypothesis generation. Certain resources are provided as support structures, and students are expected to access and use suitable tools. Communication is in distance-learning mode, which is very different from traditional instruction at Pretoria University. RBO thus uses completely different methods and activities in pursuit of its goals.

OELEs are appropriate for less-structured contexts with domain-specific thinking, and are unsuitable for formal, procedural domains, such as mathematics. Many of the broad educational problems encountered by the typical RBO learner are ill-structured, situated in social science domains, and enable the type of learning that occurs in OELEs.

- ***Cognitive puzzlement/conflict in RBO***

Cognitive conflict or puzzlement (Savery & Duffy, 1995; Perkins, 1991b) manifest themselves in RBO, as will become clear from this and the ensuing sections. Despite giving rise to a degree of learner-frustration, they serve as a stimulus for learning.

5B.2.2.2 Viewpoint of the instructor-designer

> I wanted learners to experience learning by constructing meaning as they constructed their sites. To do this I had to give deliberately vague instructions.
>
> For learners to be in charge of the process, the instructor has to let go. This is very difficult, because eventually the instructor is still responsible for the success of the course!

5B.2.2.3 Findings from survey of the learners

RBO is a highly constructivist course. References to constructivism occur, implicitly and explicitly, throughout most of the 'C' evaluations in this section. However Table 5B.5 shows responses to a series of survey questions, Questions 32.1 through to 32.6, that related specifically to constructivism. The learners rate RBO as a strongly constructivist learning experience.

Table 5B.5 Constructivist aspects in RBO

32. To what extent did you experience the following aspects of constructivism in RBO800?	**No of learners (n = 22)**			
	Very great extent	**Great extent**	**Moderately**	**Little**
32.1 Learning situated in the real world	5	12	5	-
32.2 Discovery learning	9	9	2	2
32.3 Anchored instruction	1	11	4	5
32.4 Integrated testing	1	10	6	3
32.5 Active construction of knowledge	7	10	3	2
32.6 Transfer of skills	8	8	3	3
Total	**31**	**60**	**23**	**15**

- ***Situated learning, discovery-learning, active knowledge construction, transfer of skills***

These are particularly evident. For Questions 32.1, 32.2, 32,5 and 32.6, relating to situated learning, discovery-learning, active knowledge construction, and transfer of skills respectively, three quarters of the participants rate them as occurring to a 'very great' / 'great' extent. The researcher observed concrete constructivism, as learners visibly constructed knowledge, developing publicly accessible web pages, and thus presenting their work to their peers.

RBO learners were familiar with constructivist learning from the educator's perspective. Table 5B.6 shows their responses to Question 32.7 regarding being on the receiving end.

32.7	As an educator yourself, how does it feel to be on the receiving end of constructivism?

Table 5B.6 Being on the receiving end of constructivism

Impressions	No of learners (n = 22)
Enjoyed it immensely	7
Initial frustration / challenge	11
No comment	4

These responses indicate that only seven fully enjoyed the experience. Half the learners (eleven) described initial frustration/challenge regarding constructivist learning, but found it a good way to learn if they persevered. The qualitative data following includes highly positive comments as well as indications of a mixed experience:

- ***Real-world context, and personal goal-setting:***

  A new universe to me - I LOVE the educator-as-learner experience. /
  I found that I had new ideas all the time - I enjoyed being challenged. /
  I learn a lot because I can choose what I want to do.
  I liked the experimentation and lack of boundaries. /
  Pressure!! Lots, not as much external, but self-laden /
  Discovery learning was fun. / My institution wants to extend and use my exam project. /
  Tough, yet liberating as you had a large say in how you designed work.

- ***Frustration and insecurity***

  I feel there is still basic knowledge that one needs to master. /
  The learning curve is very steep. /
  It is rather a nerve wrecking experience ... really tough because of the lack of boundaries. /
  A good way of learning, but it is time and energy consuming. /
  Frustration, irritation ... / If you persevere, you gain and retain.

  And some offered suggestions:
  Why can't it go truly constructivist and give learners their own time schedules to complete projects? /
  It's a different medium but has the limitations of conventional learning ... it should be open-ended.

5B.2.2.4 Concluding discussion

The examination of RBO against constructivist features shows a strong match. RBO is highly constructivist, despite being implemented under distance-learning conditions. The seven primary constructivist values (Lebouw, 1993): collaboration, personal autonomy, generativity, reflectivity, active engagement, personal relevance, and pluralism are all supported within RBO. Furthermore the evaluation shows that all the activities are highly contextualized in tasks relevant to the real world.

The initial discussion section highlights the occurrence in RBO of constructivist concepts such as negotiated personal goals, resources available on a need-to-know basis, real-world authenticity, and the emphasis on cognitive processes. The instructor's comments indicate that he deliberately 'lets go', so that students can construct their own meaning as they develop their sites. These factors describe a learning experience that exacts self-responsibility on the part of learners, in an environment without explicit guidance. One would anticipate that the personal responsibility for knowledge and skills-building, the lack of boundaries, and the replacement of fixed scaffolding by demand-scaffolding would cause learner-insecurity, an impression confirmed by findings in the survey. These 'negative' aspects should not be termed shortcomings. Rather they are manifestations of true constructivism.

RBO was shown to conform strongly to constructivism, except for the non-constructivist practices which are part of organizational norms, such as grading students' work and establishing deadlines. Grading of products was done by the instructor, but included a self-assessment component as well as a rating for 'classroom' participation. The request for self-paced schedules is an issue beyond the control of the instructor, but in any case, self-paced schedules would impact negatively on collaborative work, which is a key feature in RBO.

5B.2.3 Components

This section examines the occurrence of component-based learning within RBO. The knowledge and skills of each academic domain comprise basic units or components. In RBO these would relate to conceptual knowledge of the WWW and Internet, and particularly to the technical expertise required to implement web-based learning, communication, and management.

5B.2.3.1 Initial discussion

RBO includes neither explicit nor implicit component-based instruction, nor any teaching of decontextualized, basic skills, since it operates holistically. No elements are isolated in order to teach them. Nevertheless, it requires learners to be capable of both basic and integrated technical skills. For example, they must be able to manage basic abilities such as using e-mail links, but must also be able to tackle tasks such as generating animated 'gif' files, which is a complex composite skill.

Componential instruction would be inappropriate in RBO's discovery-learning ethos. Nevertheless, although there is no internal instruction of basic components, the web-classroom has links to external web sites that teach HTML, the fundamental web language.

5B.2.3.2 Viewpoint of the instructor-designer

> The course has two different types of components. In the first place there are the basic physical aspects such as basic HTML, elementary graphics, retrieving items from the WWW and placing your own content there. Then there are the integrated composite skills. Students need to be comfortable with these basic skills to figure out how to do more complex things.
>
> RBO tested students' abilities in these technical aspects. For example, they were expected to create various graphical elements in the course of their RBO tasks. However, I think one of the main problems with the course is that the technical stuff was left for the students to figure out <u>without</u> components to teach it to them.
>
> As well as the two kinds of technical component skills, there are also basic theoretical components relating to Internet terminology and concepts. Some students' basic conceptual knowledge is too low to allow them to be able to teach effectively using the Web. One student, for instance, a week into the course, asked the question 'What is a URL?'. In order to ensure that students' Internet knowledge is up to standard, they are asked to construct elementary web pages and glossaries of terms. In 2000, these were included in the songs and script of the Opera.

5B.2.3.3 Findings from survey of the learners

The survey incorporated no direct questions about components, but in open-ended responses, two learners mentioned the value of the links to the HTML tutorials.

Others discussed their non-use of the linked list of references (literature and web sites):

> *Learning material was available, but packaged differently. Due to lack of a theoretical introductory 'session', I tended not to use the instructor's comprehensive list of references. /*
> *I followed the link and printed it, but never actually accessed the material. /*
> *The instructor provided a list of references, but they seemed remote.*

5B.2.3.4 Concluding discussion

There are no explicit knowledge or skills components communicated in RBO. This is a disadvantage for learners without adequate technical skills, and some less-able learners may find the external linked tutorials too abstract. Either, these links should be made more explicit and the tutorial used as a pre-RBO course, or else attendance at a certificate course should be compulsory for learners with a skills gap. HTML courses could be supplemented by optional instruction in graphics skills.

5B.2.4 Collaborative learning

This section investigates the worth of both the collaborative and co-operative forms of learning (section 2.5.1) in RBO, determining whether the collaboration helped or hindered ultimate learning, and whether the whole was greater than the sum of the parts. Collaborative learning involves teamwork which capitalizes on each member's abilities, allocating separate roles in a joint project. Co-operative work entails small groups working together towards a stated goal or specific product. Further collaboration examined is the communication via e-mail on *e-Groups* and chat sessions, which replaced normal class contact. The subsections set out these findings and also investigate the two team tasks with respect to Johnson and Johnson's (1991) key elements of co-operation, adding the further dimension of *Communication,* which is a major factor in distance-teamwork.

5B.2.4.1 Initial discussion

Collaborative learning in the RBO course of 2000 comprised four aspects:

1. The whole-group task to produce a web-based 'virtual opera';
2. Evaluation of existing educational web initiatives by two-person teams;
3. Ongoing communication via the listserver, which was mainly used for an open e-mail forum; and
4. Membership of a newsgroup.

Each of the four is discussed:

1. Whole-group collaborative learning

The timetable and requirements for the whole-group task of creating a web-based 'virtual opera' in Unit 1 of RBO 2000 are given in Figures 5B.4 and 5B.5 in sections 5B.1.4 and 5B.2.2.1 respectively. Aware of the skills gap and varying expertise, the instructor designed a task that placed responsibility on the composite body of learners - to share and complement one another, offering multiple perspectives on the theme and building on each other's contributions. The opera project is examined under the key elements of co-operation (see 2.5.1.2; Johnson & Johnson, 1991), as well as under the separate aspect of general communication.

- *Empowerment of learners*
  The idea was for learners to plan, communicate, delegate, and self-regulate, so as to capitalize on talents for management; research; an intriguing story line, script, and rhymes; use of music files, graphics and animation; and the co-ordination of choreography for the sets and scenes. The instructor specified the dates and duration, but gave no suggestions for the title, theme or task allocation, leaving it to the students to handle planning and construction online via the listserver. Deadlines passed - a few tentative suggestions were made on the e-mail forum, and the theme *Phantom of the Internet* was chosen, but no learner was decisive or assertive enough to take charge. The instructor suggested a session in the 'chat room' and shortly afterwards a learner nominated two of the group - those who had communicated the most and made informed suggestions - for the roles of director and producer. Finally the process was underway!

  The director and producer accepted, and took charge. Other roles were allocated - some defining the story line; some taking parts in the drama (this entailed writing script and 'songs' for that character); and others researching web terminology to integrate into the script. The director delegated, co-ordinated, and selected suitable online music files, while the producer used software and web frames to hyperlink the elements into an operational production. The instructor gave a two-weeks extension, prolonging RBO.

- *Positive interdependence*
  Allocating roles was a good start. The other issue was to manage internal consistency in the opera. As contributions arrived, so the product unfolded. RBO learners had to follow the e-mail and view the dynamic opera site daily so as to make perceptive contributions that fitted what was already in place. They could spot the gaps, inform the forum of their intentions, then submit appropriate graphics, animations, poems, etc. The public e-mail forum revealed the unfolding of the opera, as well as the complexities:
  - Learner A made a suggestion to which both B and C responded, but with differing viewpoints.
  - A male made a suggestion that could be interpreted as denigrating females.
  - Tardy or busy learners delayed responses, and on making them, found that the dialogue (eight-alogue) had moved on and their contribution was useless.
  - Social negotiation led to arguments, temporary offences, apologies or assertiveness, and eventual consensus as conflicting viewpoints were channelled into convergence.
  - A learner became ill, and the producer handled it by defining an independent contribution for her, which could be linked in later.

- *Shared goals, individual accountability, and co-operative evaluation*
  There was group and individual accountability; teamwork and goals of personal excellence. Creating the opera was a joint responsibility, but the students did not all receive the same mark. The instructor knew what each had contributed and graded accordingly, awarding grades comprising both joint and individual marks.

- *General communication*
  Why the delay in start-up? It would probably not have occurred had been a face-to-face meeting up front. Another reason is that the learners did not all know each other - if they had all been MEd students who had met on previous contact modules, the inter-personal dynamics might have strong enough to foster quick decisions. A third factor was the lack of an assertive, even 'pushy' character to force-start the process.

  With regard to the effectiveness and efficiency of doing the job via distance-collaboration, asynchronous computer-mediated communication was not optimal for an eight-person project with such varied contributions. The director and producer occasionally supplemented online communication by telephoning one another, and a local class member joined the producer in physically sorting printed versions of songs and scripts - simultaneously visible - to allocate them rapidly to final positions in the score.

  If there had been a few class contact sessions, the product could have been completed in less than two weeks, instead of more than a month. In keeping with the distance-education nature of the course however, online communication was a requirement so that learners could experience first-hand the problems inherent in such ventures. Two chat sessions were scheduled on *e-Groups* to discuss the opera, but did not operate effectively. Due to technical problems, some learners could not access the *chatroom.* If it this synchronous communication been successful, it might have expedited the process.

Despite delays and frustrations, the ultimate web-based multimedia product was excellent, with a realistic structure. It achieved balance in academic terminology; web-techniques; graphics, animation and audio effects; and has an amusing storyline. *Phantom of the Internet* was a source of pride to its joint-creators, and received acclaim when the instructor demonstrated the RBO2000 website at an educational symposium and a Human-Computer Interface conference. This is line with the 'no significant difference' phenomenon which postulates that medium does not influence learning (Clark, 1994; Kozma, 1994; Russell, 1999).

2. Co-operative pairs

RBO's Unit 2 on *Distance learning and the Internet* involved co-operative pairs researching and reporting on existing web-based teaching initiatives, developing a generic interactive spreadsheet instrument to test for web-readiness, and applying it to that organisation. Of all the RBO2000 activities, this task, with its specified deliverables, was the most tightly defined, although the content was open to personal interpretation. The instructor assigned each pair an organisation to investigate, and strategically determined partners - in some cases allocating a strong student to support a weaker.

Again Johnson and Johnson's (1991) elements of co-operation and the added dimension of communication are used as discussion headers:

- *Empowerment of learners*
  The task required solid investigative research, report-writing in the format of an accredited journal, technical expertise to develop an interactive spreadsheet, and final presentation. The partners subdivided the tasks, capitalizing on strengths.

- *Positive interdependence*
  Some co-operative pairs designated separate sections of the task to each member; others developed joint products, adding sections and editing one another's contributions.

- *Shared goals, individual accountability, and co-operative evaluation*
  The co-operative evaluation system used by the instructor included both joint- and individual accountability. The partners did not necessarily get the same mark. Grades were allocated for perceived learning as well as the value of their contributions. Assessment was done by the instructor, but if they chose, individuals could inform him of their personal roles and responsibilities in the tasks.

- *Communication*
  Work distribution between the two was handled mainly by e-mail, using personal e-mail addresses instead of public communication via *e-Groups*. Likewise, documents that involve joint reasoning were transferred back and forth as attachments to e-mail. With small groups, communication and planning went smoother than in the opera, although there were occasions when learners with heavy schedules kept a partner waiting, and delayed completion.

3. General e-mail communication

E-mail on a dynamic mailing list was the forum for interaction. The instructor used it for briefings over and above the information on the website, and learners used it to communicate with instructor and classmates. All mail sent via the group-server is public, but private contact with peers as well as with the instructor could be done using the 'Ears' links from learners' desks.

In the early part of the 2000 course, when students introduced themselves and constructed the opera, there was high activity, which subsequently tailed off drastically. The instructor asked the class to comment on each other's exam-project proposals, but there was very little response. In other years lively, and even contentious, debate ensued throughout the course, as students bonded and confronted. The class of 2000 used their e-mail listserver in the process of generating joint deliverables. It did not serve as a channel for metaphorical class banter. There was very little 'chitchat' or humour, except for contributions from a past student who was one of the lifeline helpers. The nature and duration of the interaction depends on the personalities and group dynamics. When the forum is lively, it holds attention. Even those who do not participate are present - observing invisibly in anticipation. This is where the metaphor of a physical class breaks down. In a face-to-face situation, non-participant onlookers are visible and are perceived to be implicitly involved, whereas Internet onlookers can lurk anonymously.

4. Newsgroup communication

Membership of the international IT Forum (Information Technology) newsgroup via *e-Groups* is mandatory for RBO learners. In fact, the first RBO task is to learn how to subscribe to the forum. The Forum publishes an online paper is monthly, followed by open discussion on the stance and proposals of the paper. There is overlap between the Forum and the journals, *Educational Technology* and *Educational Technology: Research and Development.* Perceptions of this discussion list vary. Some learners become active participants - remaining on the Forum post-RBO, while others experience its daily offering of e-mails as intrusive.

5B.2.4.2 Viewpoint of the instructor-designer

> In the collaborative opera project, the class was put into one big group to let them feel how difficult it is to kick-start a project without clearly defined roles. I wanted the learners to experience that online learning takes longer and can easily lead to missed deadlines, misunderstandings, and other problems. I gave them the project and waited for them to start working on their Opera. Nothing happened. After a while I realised that I would have to create some urgency. This was done in the form of a session in a chat room. During this chat, students realised the importance of defining roles.
>
> The whole point is that I didn't want them to go through an errorless, fault-free automated process, because then they would not experience the frustration that their learners feel if certain things go wrong. The RBO learners had to feel, 'I went through that - it was awful - I never want my learners to undergo something similar'.
>
> The co-operative tasks were done in teams of two members each. I based the selections of the teams on a number of considerations. Firstly I put the very strongest members together in such a way that their relative strengths would be complementary (i.e. a good graphic designer and someone good at writing). Then I put the very weakest students with some reasonably strong members so that they would not be lost completely. Then I grouped the middle students together. When it came to grading the work I awarded marks to individuals and not to groups, so that weak students would not benefit from the work of their stronger team-mates, nor would stronger students be pulled down by their weaker partners.

5B.2.4.3 Findings from survey of the learners

Several of the questions relate to collaborative learning and communication, and their central roles in RBO:

15	How did you experience interaction with your classmates - e.g., useful /supportive / complex / frustrating, etc?
16	Were there issues relating to e-mail communications and the chat sessions - other than technology-related - that were problematic, e.g. misunderstanding of meanings or intentions?
18	Did you use any other means of communication with the facilitator or other learners?
21	One of the problems in collaborative learning is getting started. What factors influence group members to take initiative?

The responses to Question 15 on personal interaction are shown in Table 5B.7, classified into three groups and clarified beneath the table by their elaborations. Some responses (not shown) related to the co-operative work with a single partner and those responses were mainly positive.

Table 5B.7 How did you find the interaction with classmates? (n = 22)	
Positive experience	4
Mixed feelings / Useful, but frustrating at times	12
Negative experience	6

- ***Collaborative interaction***
  There were insightful and thought-provoking comments on whole-group online collaboration:

  It was frustrating in that we did not all work with the same urgency. /
  Working collaboratively without face-to-face contact was a recipe for irresponsibility on my part. /
  A simple decision takes days to pan out. ...

  The Opera - whole group collaboration: the aspects that could be very time-consuming due to lack of skills not yet acquired were done collaboratively. Many hands and brains made the assignments flow, while learning simply happened.

  Second group tasks - pairs: I noticed the clever grouping of the slow and the fast workers, the strong and the weak students. A commendable skill to use when leading a group task. I also appreciated the formative feedback.

- ***E-mail contact***
  Five of the six who responded negatively in Table 5B.7 were from the class of 1999, where online conflict had occurred:
  Too much irrelevant online bickering. /
  Tedious and sometimes irrelevant. /
  All those e-mails every day ... I found them intrusive

Some learners felt the daily interaction did not come up to expectations:
I felt frustrated there was so little interaction between students and that they weren't really supportive of each other (except for the Opera). They all stuck to themselves. /
I like discussion and debate - it happened to an extent, but the human factor wasn't there. /
I prefer instant response.

Question 16 relates to problems with online communication. Apart from more references to the 1999 online 'flaming' (conflict), comments acknowledge that misconceptions and ambiguities occur online, which would have been speedily resolved in direct contact.

- ***Chat room sessions***
  Several learners were unable to access the chat room, but those who had, made suggestions:
  It should be regulated, so that everyone gets a turn to speak or respond. /
  My initial lack of expertise made my responses slow. When I was misunderstood, the conversation flowed so fast that explaining myself was no longer relevant and I just let it go. I did not find the experience hindering, though. I learnt a lot about communications and online chats. /
  It would have been much better if it had been controlled, e.g. a leading question and chances to contribute. /
  Timing of the chat ... I could not make one of the sessions for work reasons. Maybe a chat archive would be a good idea, so I could catch up.
  (Note: there is actually a chat archive facility on the service provider)

- ***IT Forum news group***
  Students gave their varying impressions of the international IT Forum group communication:
  It was irritating - all those e-mails. I was glad that once the module was over, I could unsubscribe. /
  It cluttered up my computer.

  Others participated actively and regularly, and stayed on the Forum after completing RBO.
  Stimulating - I enjoy contributing. /
  I savoured the daily debate and anticipated each new paper on ITForum.

Question 18, the responses to which are given in Table 5B.8, investigates to what extent learners supplemented e-mail by other forms of contact:

Table 5B.8 Did you use any other means of communication? (n = 22)	
Yes	8
No	7

Most co-operative learning pairs phoned each other, and those of the 1999 class who lived near each other had met. In 2000 the wily instructor paired students who lived far apart. As stated in 5B.2.4.1, the opera generated direct communication - phone calls between producer and director, and face-to-face between the producer and a local co-learner in the final stages of integrating the material.

The problem addressed by Question 21, namely, getting started, is experienced more in online collaborative learning than in face-to-face teamwork. Minor delays occurred in the small teams, but delay was a major issue in the large-group opera task. Students had different ideas about the factors that influence group members to take initiative. It appears that, all else failing, deadlines and frustration force the issue. In general, many factors contribute:

- ***Confidence, lack of self-confidence, time, work commitments***
  A person may fear exhibiting one's lack of skill or knowledge ... it is safer to lurk in the background until one has the self-confidence to make a contribution. /
  So "nice" ... so scared to be too forward ... someone has to get started and stick your neck out. /
  The instructor did some encouragement, coaxing, "When are you going to start?". /
  In desperation I offered to be the director. At least we got some direction then and found that the actual task was less daunting than the prospect.

  - ***Dynamics between isolated distance-learning and collaboration online***

  Both the above situations are non-ideal, yet each can add something to the other to bring about balance. Some general remarks provide different perceptions about the balance:

  I learnt that even with a listserv and co-operative group projects, web-based courses can be isolating and lonely. / ... not an optimal environment at all. /
  I like to get on with a job ASAP in a focused way and interaction interferes with this. /
  My partner was under pressure at work and just disappeared into cyberspace, delaying our efforts. If there had been face-to-face contact, it been much harder to do this.

  Never having been a full time student, I was accustomed to working on my own with very little interaction, so the aspect of working independently was nothing new.

  Feeling free to learn from others definitely made me learn more and enjoy the process. It is exciting to see what is possible and try to improve on that by putting your own stamp of individuality on it. I am better at japaneering than engineering.
  Note: this comment refers to the opportunity of viewing the code underlying web products and re-using it with modifications and enhancements.

  I learned lots about the process of creating a climate and a community with which to promote such learning. / I appreciate the immense impact of computers on groupwork!

5B.2.4.4 Concluding discussion

The evaluation shows how teamwork can generate products of a standard and extent way beyond what individual learners could produce. Combining different forms of expertise and complementary abilities is synergistic, contributing to the quality of end-products. Both the opera and the two-person tasks comply with the recognized characteristics of co-operative learning, including interpersonal skills as learners share goals and acknowledge interdependence.

The main contribution of this study is the light it sheds on **online collaboration**. The evaluation, especially the investigation of the collaborative opera experience with its delays and complications, highlights the complexities of online collaboration. First, there was the difficulty of online decision-making and planning. Second, it was cumbersome and inefficient to assemble a multi-media project by virtual collaboration.

Do these complexities represent a shortcoming in RBO? To the contrary they comprise strengths. The instructor permitted the problems to occur - a deliberate tactic to make a point and expose learners to the issues first-hand. The instructor- designer achieved his aim of demonstrating how and where web-collaboration is appropriate - a valuable lesson for learners about to become Internet instructors. A real shortcoming of collaborative work, however, is that a team member/s can delay the project. This problem is exacerbated in virtual collaboration, because the offender can disappear into cyberspace, ignoring online calls.

Working collaboratively was further exposure to the integration of learning theories - this time, the close coupling of collaboration and constructivism. Collaborative discovery-learning assisted personal knowledge construction and interpretation of meaning.

5B.2.5 Customization

Customized learning is implemented in many different ways – varying from in-built properties of computer-based learning systems to non-technological attributes of a learning event or experience. Section 5B.2.5 reviews RBO to determine how it customizes learning to the requirements of individual learners. The evaluation also investigates the extent to which RBO is learner-centric, where learner-centricity, according to Jonassen, Campbell and Davidson (1994), emphasizes supporting learners rather than controlling them.

5B.2.5.1 Initial discussion

The original perception of customization views it as a technique implemented by the branching options in programmed learning and CAI lessons. Constructivist customization, as practiced in RBO, is related to more to philosophical human factors underlying the learning process, than to hardware or software attributes of instructional technology systems. RBO personalizes the course to each learner by aiming for:

- Self-actualization, meeting the requirements and preferences of individual learners, so as to provide them with a fulfilling and useful learning experience;
- Self-regulation, as learners take active responsibility for the learning process;
- Self-direction as learners decide for themselves what to tackle as an exam project and how to set about it; and
- Augmentation of understanding by *situating it in personal experience*, supported by scaffolding.

Each learner emerges from the learning experience with different knowledge and expertise. The role of the designer is to support and guide those individual processes.

This individuality is also evidenced by the class website, where each 'desk' conveys something of the owner's personality and customs. Although constructivism de-emphasizes grading and competitiveness, the desks gave full opportunity for achievers, graphic artists, and web 'techies' to display their skills.

5B.2.5.2 Viewpoint of the instructor-designer

I designed the course with as many options as possible. The learners had to design their own desks – both the mini-desk graphic in the classroom and the picture of the desk that formed the index to their own work. The students could select the theme of the opera for themselves. Their major project was also on a theme of their own choice.

In other words, I did not customize the course, but made it customizable. Each learner had to personalise RBO for him/herself, i.e. auto-customization rather system-customization.

5B.2.5.3 Findings from survey of the learners

The questionnaire included questions on individual needs and the extent to which learners encountered personalized learning in RBO. Moreover, their perceptions of grading and the worth of RBO as a career benefit were addressed.

35 What are your personal learning preferences, and in what way did RBO match/mismatch these preferences?

36 The conventional instruction paradigm includes marks at intervals for students' interim tests / assignments. How do you feel about the lack of this in RBO?

37 How did you find the course useful in your personal or professional life?

Most of the responses to Question 35, shown in Table 5B.9, indicate that learners were able to personalize the learning experience to their own particular requirements:

Table 5B.9 Realization of personal learning preferences in RBO (n = 22)

Extent of personalization perceived	No of learners
Fully personalized	10
Personalised to a certain extent	9
No personalization	2

Elaborations to learners' answers were compiled, and are listed in Table 5B.10 and 5B.11, showing personal learning preferences that were realized in RBO, as well as some aspects that were not matched.

Table 5B.10 RBO and learning preferences

Learning preferences that were realized	**Number of students (n = 22)**
Constructivist learning / active learning	4
Experimentation / trial-and-error/ hands-on / experiential learning	4
Holistic, contextualized learning	2
Open-ended approach to tasks and projects / we could be creative	3
Asynchronous nature – work at own time in own place	5
Independent learning / working in my own way	4
Contact with fellow students / groupwork	3
Practical skills	1
Sense of achievement	2
Learning preferences that were not realized	**Number of students (n = 22)**
Clear guidance and instruction	3
Face-to-face learning / direct contact with fellow-students	4
Discussion and debate on issues of the domain / Academic stimulation	2

As education students, they know the jargon and unprompted, they used the correct terminology to indicate clear preference for active, contextualized, constructivist-style learning (13 of the 22 - first four rows of Table 5B.10). The lack of boundaries and constraints gave them freedom and convenience to work independently in their own place, time and way (nine learners – fifth and sixth rows of Table 5B.10).

The responses regarding preferences not realized showed that seven learners missed the clear guidance and class-contact of conventional learning. A learner raised the pertinent issue of matching personal skills and learning preferences within RBO. Does the purpose of RBO relate to technical web skills or is it about didactics and learning? The answer is the latter – the prime aim is to promote sound use of the Internet and WWW to support teaching and learning, but certain students may not perceive it that way. Such students customize RBO to display their technical superiority and graphic web design expertise.

Table 5B.11 shows the views that emerged in answering Question 36 on the lack of interim marks (grades) in RBO. In general learners were ambivalent:

Table 5B.11 Would learners like marks on an ongoing basis? (n = 22)		
Yes	**Immaterial/ not an issue**	**No**
5	10	3

- ***Interim scoring / feedback***

Don't bring it in / You can do it or you can't, and you know ... /
The lack of conventional marking systems is one of its greatest strengths.

Seven of the ten students who were content not to receive ongoing marks, would have liked more comments or impressions from the instructor:

Very frustrating not knowing what your work to date is worth. /
I did not require marks, but wanted *__feedback__* *to know whether I was on track or off track.*
As a person - very approachable. During the course - no: no feedback. I had to wait until the end of the year to receive my mark in the official report from the university. /
I understand his position. He prefers to step in only if he has to. This is part of his constructivist outlook that learners must discover it for themselves, which they indeed do /.

I wasn't bothered by the lack of a mark, because I wasn't focussed on the outcomes. But I missed caring interaction from the instructor towards learners, if the instructor had made comments such as: "why aren't you participating?", "that was something good that you said", or "you are missing the point". The learners had to fight it out. There was no adult care for learners.

The previous remark was made in the context of the class of 1999, where there was online conflict and aggression between certain learners, and withdrawal on the part of others. Deliberately, the instructor observed, but did not intervene. Although he may have made the right decision in avoiding contentious issues, it would have encouraged learners had he made regular input on non-controversial matters. In general, they found him very approachable, but the class of 2000, more so.

A people-oriented person / His enthusiasm is pure joy - he motivates his students / He is prepared to listen to your problems / His understanding attitude when you have problems, definitely motivates one to follow up with trying one's best. / Always keen to hear from you.

Question 37 asked students to consider the worth of the course in their personal or professional lives. Responses were mainly positive, as shown in Table 5B.12 and the comments following.

Table 5B.12 Was RBO useful in your personal or professional life? (n = 22)		
Yes	**No response**	**No**
17	4	1

Very useful and I'm excited - I'm going to set up information portals concerning my different interests. /
I'm experimenting with presenting my material on the Web. /
I want to give web-based courses (8 learners). /
Have made my own website for professional use. /
Broadened my perspective on group dynamics / collaboration (2 learners).

And finally:
People can learn wherever they want, however they want - information available 24 hours a day. That's progress and civilization!

5B.2.5.4 Concluding discussion

Customization, RBO-style has nothing to do with customized user interfaces or learner-controlled software. Rather, it integrates various tenets of contemporary learning theory by offering constructivist customization in a context of self-regulated cognitive learning.

The instructor's intention was to offer a course that learners could take in an immersed web-based distance environment, choosing context and content to suit their individual needs, supplemented by electronic distance-teamwork to mitigate against isolation. This design aim was largely successful as learners were able to auto-customize the RBO experience to their own circumstances and requirements. A high number (19 of the 22) felt they could personalize the course to their needs.

There may be a shortfall in direct guidance and support. The open-ended responses show that approximately a third of the learners preferred the structures and guidance of conventional learning, while the others appreciated RBO's unconventional presentation.

Another shortcoming, expressed by one learner, and also perceived by some other learners and the instructor (Cronjé, 2001a) is the way some learners customize RBO to demonstrate their technical expertise. This is a further example of incorporated subversion, whereby certain learners appear to use RBO to compete in demonstrating advanced web-design abilities. Some of the less technically-skilled did not appreciate being perceived by fellow-learners as less competent. Although technical skills can simplify a web-educator's task, the purpose of RBO is to present a far broader picture. Technical prowess is not the prime aim in RBO, and that is one of the reasons behind the collaborative work - to capitalize on varied abilities and compensate for inadequacies. Only a certain basic technical standard is actually required of each learner.

5B.2.6 Creativity

To evaluate creativity in RBO, this section must investigate certain basic tenets of creativity. The prime issue to examine is the use of original and novel means to engage learners and support their learning. Creativity is closely coupled to affective aspects, such as the motivation of learners. The RBO model is compared to various conditions proposed by Dick (1995) for producing creative instruction, such as learner analysis to match their interests, a supportive environment for the designer of the instruction, participatory design, and use of elements of Keller's (1987) ARCS model. A highly relevant issue is the exploitation of technological and multi-media opportunities. It should also be determined whether creativity in the instruction engenders corresponding creativity in its target group.

5B.2.6.1 Initial discussion

This subsection discusses the researcher's impressions of creativity and motivation within RBO.

- ***Originality and novelty***

RBO's structure, content, and presentation are novel and original. While much web-based training is presented using commercial products that provide web-based instruction and course administration in an integrated package, the RBO instructor took an original approach, custom-building his site and procedures. A way of generating creative approaches is to consider instruction in its totality early in the design process (Reigeluth, 1999). This facilitates an early vision of the ideal product. The RBO instructor's specific goal was to present a web-learning experience based on the artefacts, events, and activities of a real-world classroom, and his efforts were focused throughout in that direction.

Course assignments and the nature of the collaboration change each year, entailing re-design of timetable and tasks, and references. Course structure and outcomes remain the same.

- ***Dick's conditions of creativity***

Dick (1995) suggests means towards producing creative instruction (see 2.5.3.1):

  - **Innovation and novelty**
    RBO's novelty is structured around its metaphorical classroom-on-the-web. Metaphors are a an aspect of cognitive learning, but are equally relevant to creativity as they attract and support learners by inducing an appropriate 'familiar' environment. The relaxed and humorous class idiom engenders enthusiasm and creativity within the students in turn, as they enjoy the freedom to communicate something of themselves in the process of designing and building their desk and its links to pages about their hobbies; academic work and publications; and their cumulative RBO portfolio. Colours and animation are the order of the day.

- *Awareness of learners' needs / relevance*
  This has been discussed in the previous section, 5B.2.5 on customized learning, reinforcing the overlaps in relationships between the learning theories of the HCMm framework.

  - *Participatory design - involving learners on the team* (also Willis, 2000; Reigeluth, 1996c)
    Participatory design has been used in RBO. Following positive criticism by a learner of the design of the 1999 classroom-on-the-web, the instructor invited that student to work jointly on a facelift for the classroom of 2000.

  - **A supportive environment for the designer**
    This is addressed by the designer himself in 5B.2.6.2.

  - **Exploitation of technology and multi-media**
    RBO is founded on sound educational use of technology and multi-media; in fact, teaching with technology is the reason for its existence. The collaborative project to design and build a multi-media virtual opera,was creative not only in the audio, visual, and textual aspects, but also in the way it exploited distributed technology to develop administrative and technical teamwork, being managed and hyperlinked by remote control.

- ***Use of strategies from Keller's ARCS model***

Keller's model is primarily geared for enhancement of conventional teaching and learning structures and is not altogether applicable to RBO. The classroom metaphor grabs initial attention, although when frustration-in-isolation occurs, it may not continue to hold attention. Since the exam project is directly focused on learners tackling issues of personal career benefit, RBO meets the criteria of attention and relevance. For those who complete it, it also complies with the S of the model, in that they are well satisfied.

- ***Creativity that engenders creativity***

Finally, there is the matter of creativity that engenders creativity, as mentioned in 2.5.3.1. RBO is highly successful in inducing creativity in the learners. However, it is important that creativity remains supplementary to learning. Gimmicks, animation, special effects - whether used by the educator or the learner - must be used in support of the information communicated and not be the content themselves. In evaluating learners' products, the instructor's prime aim is to assess their grasp of the role of the Internet in managing and communicating instruction, and not to judge a graphic design competition.

5B2.6.2 Viewpoint of the instructor-designer

The initial creativity in the course is based on reversing the traditional way of doing things, restructuring the patterns (De Bono, 1970). Whereas in a traditional contact class on the Internet, students would gather in a computer laboratory and surf out to various sites, in this course, students stayed at home and surfed into class.

Other elements of creativity centred around letting the learners do things that they would not have done in a normal classroom such as designing their own desks. The most radical form of creativity included letting them create Internet versions of things that they would find in real life but not usually on the internet – such as the ' Virtual opera'.

The supportive environment was personally encouraging. The students showed it by their enthusiasm, and so did my colleagues, who would peer over my shoulder as I built classrooms. The IT Forum community also visited and commented.

5B2.6.3 Findings from survey of the learners

The survey incorporated questions on creativity, innovation, and motivation in RBO:

34.1	RBO is offered in an innovative, unconventional manner. Describe the innovative aspects you experienced, both in terms of the presentation of the module and in the content of the assignments, and how you feel about the approach.
34.2	What aspects and styles of this innovative approach did you incorporate in your own RBO project, or plan to use in your subsequent teaching ethos?
22	Were you at any time so engaged and absorbed by certain activities that you seemed to 'flow' along with it, experiencing satisfaction / glued to the computer?

Question 34.1 asked students to highlight features of the online course and its classroom that impressed them as innovative and different. The findings are shown in Table 5B.13:

Table 5B.13 Innovative aspects of RBO		
Aspect	**No of students (n = 22)**	**Elaborations**
Online classroom environment	5	- New way to learn / Unconventional concept - Appealing approach, design and presentation / Stimulating and motivating - Genuine learning / Communications forum - Learning could actually occur in a virtual simulated class environment.
The tasks and the project	10	- Very open-ended, was never limited - Assignments creative and innovative, especially the opera - The virtual opera integrated different ideas and creativity - I learned a lot. - Because responsibility was left up to learners, we would put in more than was expected. - Tasks were interesting, appealing, unique, and exciting. - Freedom to do a relevant project in line with own taste - to do own design, using own choice of software, to put in major effort on product you could use yourself - Opera most original, but as a lover of good music, I was frustrated not to hear the real thing. - Tasks were allocated that seemed to be matched to the students (1999).
All work done being made available to all participants	2	- Improves and creates knowledge - Enhances learners' self-esteem when others appreciate your efforts - I learned much from the work of the others.
Innovative use of technology	3	- I discovered the immense impact of computers on groupwork by remote students. - This medium is powerful - it was the first time I had experienced this kind of interaction amongst people in a learning environment. - There are so many possibilities for using the web in teaching others and learning myself.
Challenge: new tools	3	- The tools had to be mastered at our own pace, with very little help. - My lack of expertise made me slow in the chat room. When I was misunderstood, the conversation moved on so fast that explaining myself was irrelevant and I just let it go.
Do not experience the RBO approach as significantly different	3	- Some of the other MEd modules combine class sessions with distance-learning, with learners posting products on their own web page, so RBO is not unique. (*Note*: This is because other modules adopted the RBO approach!)

Table 5B.13 categorizes the responses and incorporates learners' substantiations into the table. Some of the aspects mentioned by students are closely associated with Dick's conditions for creative instruction, mentioned in 5B.2.6.1. The students experienced the classroom metaphor as innovative, motivating, and functional. In particular, they considered the activities (tasks and projects) creative and relevant, and were able to use them to match interests. The course made innovative use of technology and demonstrated the value of Internet technologies in teaching and learning, so that learners students felt encouraged to try them out in their own careers as educators. Their responses to Question 34.2, relating to this aspect, are classified in Table 5B.14 which lists aspects of RBO that they would, in turn, use with their own learners.

Table 5B.14 Aspects of this approach that I have used / would use in my own teaching

Aspect	No of students (n = 22)	Elaboration
Forum for class communication	6	- Listserv - Bulletin board - Electronic groups
Gave them open-ended projects. / I want to stimulate my students with innovative ideas for activities.	3	- Their initiative surprised me! - Something unusual is a stimulating challenge and I want my students, in turn, to experience that.
Constructivism	3	
Group projects	3	- Used what I learned and acted as a facilitator - Would give a challenging assignment to a few people, strategically grouped for efficient work output
Learners constructing their own web sites / online portfolios	2	- Viewing fellow-students' work
All the work done being made available to all participants	2	- As above
Interactive participation / critical thinking and HOTS	2	
An Internet tool as additional help to facilitate learning	1	- For supplementary help and guidance
Classroom metaphor	1	
Would not use any of those aspects	1	- This exercise cured me of RBO.

- ***Reservations***

One learner stated that he liked the approach, but would like ongoing feedback, and would provide it in any online teaching he himself might do. Another claimed that RBO, the fully online course, was:

> *... by far the loneliest I've experienced - I missed personal contact.*

In contrast to those who appreciated the 'fun' nature of RBO, a certain learner felt that the 'frivolous' nature of the assignments undermined the credibility of the course.

One was consistently critical. During the duration of the course, that student had disturbed equilibrium by using the forum to criticize classmates' contributions. Now, on completing the questionnaire, the student took the opportunity to define the feature that he/she found innovative:

> *I enjoyed the freedom of expression, but clearly the majority of my classmates still needed to be spoon-fed. I was disappointed in their non-performance.*

The primary motivating force varies from learner to learner. When asked in Question 22 about activities that engaged and absorbed them, some described flow (Csikszentmihalyi, 1990) - being 'glued to the computer' and working far longer than intended when generating their own products. The opera project had stimulated most of the class of 2000, who found it fun and challenging to develop their contributions. It had been good to work together, exciting to watch it grow daily, and rewarding when one's own contributions were linked in by the producer. The personal exam project was easier to control with its single, personal involvement, and this had induced high motivation in several. Yet others had really enjoyed following and contributing to the e-mail discussions.

5B.2.6.4 Concluding discussion

The findings in this investigation show that the instructor achieved his aim of restructuring learning patterns, so as to generate a highly creative and innovative learning experience. The novel classroom metaphor is effective both in motivating learners and in stimulating cognitive processes, a relationship previously mentioned in Section 5B.2.1 under discussion of the affective-cognitive connection.

The course content relates to educational use of the new technologies, and RBO is an example in this respect. It exploits technological opportunities, conveying its message and receiving learner-input in an original, yet platform-independent manner, since it is not tightly coupled to any hardware or software systems.

In discussing what is unconventional in RBO, some learners again raised the matter of low-level support, and would appreciate more explicit guidance. This shortcoming should be addressed either by explicit teaching within RBO or by raising the entry requirements to ensure higher initial skills. Motivation entails not frustrating learners, and these issues should be resolved.

5B.3 General

This section proposes how the five facets of a learning environment are made up in RBO and also briefly discusses its use of technology.

5B.3.1 Facets of the RBO learning environment

Table 5B.15 shows Perkins' five facets of a learning environment (Section 3.5.4; Perkins 1991a) and their associated resources/implementations in RBO.

Table 5B.15 Facets comprising the RBO virtual classroom
(Perkins, 1991a)

Facets that comprise a learning environment	Corresponding implementation in RBO
Information banks	RBO web-based ‘classroom’ Technology manuals Online tutorials and help facilities 'Techie' friends
Symbol pads	Computers with Internet connections Scanners Rough notes and representations
Construction kits	Web-authoring systems: Html, Frontpage, Dreamweaver, Netscape Composer, CorelPhotoshop. PaintShopPro, Arachnophilia, Adobe, Shockwave Other: Spreadsheets, databases.
Phenomenaria	Internet and World Wide Web
Task managers	RBO online directives (in web-classroom and via e-mail) Instructor/facilitator Individual learner Co-learners

5B.3.2 Technology in RBO

Technology is the core subject matter of RBO, due to its role as a course in Internet-based Learning. Virtually all RBO work was undertaken online, with the computer serving as source, conduit, and tool. Apart from accessing information in the 'web-classroom', students were engaged in using various packages and Internet-tools of their own choice, and about half would have appreciated (optional) opportunities for explicit teaching in using these systems. Internet- and Web- skills were essential, yet were partially assumed. As described in Section 5B.2.1.3 on cognitive learning in RBO (Tables 5B.2 and 5B.4), nine learners were new to the Internet and five experienced a skills gap or found the pace too fast. There were very few complaints (only three) about technological problems. Despite the constructivist frustration experienced, at the end of the course 17 of the 22 respondents classified themselves as 'webbies' (Table 5B.3 in Section 5B.2.1.3) and stated that they found RBO useful in their personal/professional lives (Table 5B.12 in Section 5B.2.5.3). About half plan to use the Web in their careers as educators; intended use is elaborated in Table 5B.14 in Section 5B.2.6.3.

The other major aspect of computer usage relates to online communication, which gave rise to some problems (Sections 5B.2.4.1 and 5B.2.4.3). Nevertheless, despite complaints and frustration regarding decision-making-by-distance and construction of the opera, the ultimate web-based multimedia product was gratifying to those who generated it, and enjoyed by those who viewed it and gave feedback. In both the *Opera* and the co-operative pairs, the resulting work benefited from a blend of knowledge and expertise, and optimised the skills mix of its creators. This is line with the 'no significant difference' phenomenon relating to learning by different media (Clark, 1994; Kozma, 1994; Russell, 1999). Undoubtedly, collaborative learning is more efficient in a contact-environment. However, the Internet, Web, and networks in general have made computer-mediated collaborative work possible. In distance-learning situations where formerly, teamwork would have been impossible**, it is now feasible** due to these supportive technologies.

5B.4 Conclusion to the RBO evaluation

This section, Section 5B of Chapter Five describes an evaluation of RBO800, a masters-level module in Internet-based Learning, from the perspective of learning and instructional theory. The investigation was two-pronged - the researcher personally investigated the 2000 presentation of the module (virtual observation) and also conducted a survey of RBO, namely, a learner-evaluation with the classes of 1999 and 2000, using the six elements of Hexa-C Metamodel as a framework.

How elements of learning- and instructional design theory integrate in RBO

The investigation based on these six elements showed strong connections between them. RBO is about learning-by-doing as learners take responsibility for their own learning, with little guidance. It evidences strong constructivism - experimentation, challenge, lack of boundaries, discovery-learning, personal interpretation. The constructivism in RBO is a complex variant - it is **constructivist online collaboration** - an integration of three paradigms, each of which is challenging, even daunting, in its own right. Collaboration by distance is inefficient and complex, yet - made possible by the Internet - it is collaboration where formerly collaboration could not have occurred. Capitalizing on technology, on learner's personalities, and using their varied expertise in teams, collaboration is an added dimension to mitigate against isolation in distance learning.

However, RBO need not have been distance-education - it became so by choice. The MEd modules at the University of Pretoria are traditionally offered as contact teaching. But the RBO instructor, setting out to teach about the Internet, decided to do so via the Internet - a creative strategy that would give a concrete experience of web-based learning to intending web-educators. To help the learners feel more like learners than like educators, he presented it in the metaphorical classroom, where each learner could creatively customize, not only their desk, but also the direction, depth and breadth of their exam project. Auto-customization occurs as each individual uses the course to move in relevant directions and assume responsibility for their own learning. The subtle humour in the course is a contemporary approach, whereby amusing approaches are used as communication media. Academic communication, too, need not be sober and sombre.

The purpose of creativity in instruction is to obviate against learner-boredom, and to engage and motivate learners. Motivational and affective issues do more than just motivate learners - affective aspects are also strongly connected to cognitive learning. In RBO the affective structures are achieving the first objective - to engage learners and gain attention. However, the second matter, the affective-cognitive connection may be lacking, as evidenced by requests for more feedback and guidance, and learners' lack of confidence. But RBO falls short on the affective-cognitive connection, causing some to learners to feel overwhelmed and discontinue the course. The shortcoming could be addressed by supplementing RBO directly or indirectly with component-based instruction of basic knowledge and skills.

The instructional design of RBO

Table 5.1 sets out the designer's aim for RBO, 'to place educator-cum-learners in the position of Internet-based learners, giving them first-hand experience of being on the receiving end of an Internet course and doing so in a web-based classroom'. This has been effectively achieved by a combination of inter-related learning strategies. FRAMES was shown to successfully support cognitive learning within a paradigm of constructivist collaboration. The creative design of the learning event facilitated auto-customization by individual students.

Section 5C - *Case Study Three: Mkambati 2000*

The third learning event analysed using the Hexa-C Metamodel is the Mkambati 2000 Project - a fieldwork trip and practical project in Ecotourism. The structure of the study is identical to that of Sections 5A, 5B, and 5C. In the first part of Section 5C, the multi-discipline of Ecotourism is outlined, after which the scope and activities of the project are described, using a text box for the narrative.

The second and major part of the section is devoted to discussion, evaluating the project under the six elements of the HCMm framework. Under each element, the project is examined with respect to the appropriate learning theory or characteristic. As explained in Section 5.1.3, each section is further divided into three perspectives:

(vii) Initial discussion by the *researcher*;

(viii) viewpoint of the *designer* of the learning event (who is also the course lecturer); and

(ix) *learner-data* - quantitative, but mainly qualitative, obtained from surveys and interviews;

before ending with a *concluding discussion*.

5C.1 Introduction to Mkambati 2000

5C.1.1 Immediate domain and purpose

The University of Pretoria offers a postgraduate course called Ecotourism. It was initially offered in 1996 by the Department of Geography as one of six subjects for a BSc Honours (fourth-level) degree in the broad field of ecotourism. Since 2000 it has been presented by the Department of Tourism Management and aimed at a broader target group. It is a focused course in the principles and practice of the ecotourism discipline, consisting of fourteen weekly two-hour contact sessions. There is no prescribed book, but the learners are given an extensive bibliography including journal articles. They collect information from the library and Internet, and present topics during class session. Classes are informal, with high learner-participation and discussion.

The course has a balance between theory and practice. It incorporates a field trip and a collaborative project, during which learners conduct intensive research and analysis aimed at proposing solutions to a real-world problem. The class of 2000 spent a week at the remote Mkambati Nature Reserve on the so-called Wild Coast of South Africa, investigating future development and drawing up planning guidelines in harmony with the fundamental principles of ecotourism. This practical project is the subject of the third case study.

The reserve has unique natural attractions in pristine condition, but facilities are run-down and the situation is fraught with complications and conflict. Management is in the hands of provincial nature conservation officials, desiring to optimize utilization of their mini-paradise, yet facing:

- Budget constraints;
- Responsibility for the preservation of fauna and flora - including a unique species;
- Game poaching;
- Decay, poor maintenance, and poor access roads, along with complex bureaucratic procedures which make purchase and repair cumbersome;
- Issues of accommodation and hospitality, which they would prefer to privatize, since their training and expertise is primarily in nature conservation;
- Barriers to such privatization, in that private companies require long-term guarantees and reasonable prospects of profitability before making heavy investments; and
- Unrealistic expectations by the local community of benefits from the reserve.

The learners worked in four groups to investigate:

(i) Fauna and flora;

(ii) activities for the ecotourist;

(iii) culture and community; and

(iv) accommodation and facilities.

Basic information regarding the reserve was supplied. Learners were required to supplement this and their class-based learning with independent research and to integrate theory into their investigations.

5C.1.2 Operational environment and learners

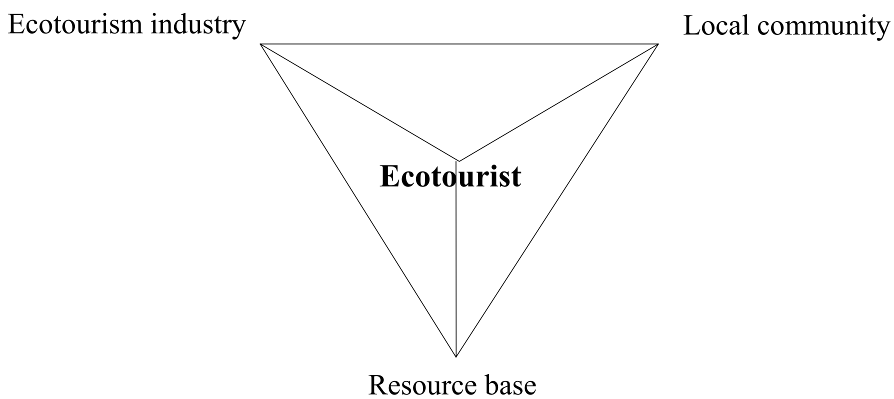
The Ecotourism course is taken by honours- and masters-level students from disciplines such as environmental studies, environmental education, sociology, botany, landscape development, tourism, etc. This multi-disciplinary student base synergistically brings wide expertise to the collaborative environment, impacting positively on the type of task that can be tackled as a practical project. Class size is ten to fifteen students annually, mostly fulltime students with part-time employment. The class of 2000 comprised fourteen learners aged between 22 and 33, of whom twelve went on the field trip. The two who were unable to participate subsequently discontinued the course.

The definition of *ecotourism* used in the course defines it as:

- An enlightening, interactive, participatory travel experience,
- to natural and cultural environments,
- making sustainable use of resources,
- providing economic opportunities for industry and local communities, and
- implementing sound environmental management beneficial to all role players (Hattingh, 1996, cited in Queiros, 2000b).

These elements are represented by the *ecotourism tetrahedron model* (Figure 5C.1), which sets out the fundamentals and their interrelationships. This model serves as the basis of the theoretical and practical components of the course. The *resource base* on which the ecotourism product is based can be natural or cultural, and its sustainable usage is the key to ecotourism. The *local community* should be involved in an integral manner in the venture, and aspects of their culture are, in turn, utilized in the tourist product. The *ecotourist*, at the centre of the model, requires an interactive, enlightening experience with active participation - more so than the traditional tourist. Finally, the *ecotourism industry* plays a coordinating role in determining that the other three fundamentals are in place (Queiros, 2000a).

Figure 5C.1 The Ecotourism tetrahedron
(Adapted from Bewsher & Hattingh, 2000, cited in Queiros 2000a)



5C.1.3 Roles: the project designer, facilitator, and the researcher

The leader of the course planned and designed the format and requirements of the Mkambati 2000 Fieldwork Project. Thus, once again, the roles of lecturer and instructional designer converged. During the previous fourteen-week class-based period, she had served more as a facilitator than a traditional lecturer. Students presented material, while she planned, co-ordinated and concluded the discussions. During the actual fieldwork and project write-up, she undertook the role of project leader-cum-facilitator, along with a professor who was a co-lecturer in Ecotourism.

The researcher accompanied the class on the fieldwork as an observer-participant. She joined in the activities, and contributed in a practical way by helping with logistics. Subsequently she evaluated the project, surveying the twelve student-participants and interviewing the course leader.

5C.1.4 Scope and events of Mkambati 2000

The narrative in Text Box 5C.1 describes the field trip, the dynamics of the problem, and the progress of the project. The text box is followed by a map of the reserve and photographs.

Text Box 5C The Mkambati 2000 Project

The class of 2000, accompanied by the course leader-facilitator, a co-lecturer, and the researcher, undertook a one-week field trip to the remote Mkambati Nature Reserve to study the situation and suggest ecotourist planning guidelines for future development. The fieldwork was followed by collaborative proposals and documentation.

The problem and the task

The region is characterized by pristine coastal and estuarine topography, as well as by grasslands, gorges, and small-scale occurrences of two kinds of forest. Mammals, birds and marine life draw nature-lovers and fishermen. Some of the particular attractions are a unique species of palm tree - the Mkambati palm *Jubaeopsis Caffra*, a fragile breeding community of endemic Cape Vultures *Gyps Coprotheres,* loggerhead turtles, and kingfish. The reserve has unique natural and cultural attractions, but due to poor infrastructure, is not easily accessible. The facilities and infrastructure are limited and run down. Like various other nature reserves, it is embroiled in contentious political and community issues. Its future is under the spotlight due to unresolved tourism policies, differing management proposals, and uncertainty regarding future control over its accommodation and hospitality facilities. Current management both of conservation and tourist matters, i.e. of all aspects of the reserve - ecological, preservation, facilities, and tourism - is in the hands of provincial nature conservation officials, running their secluded paradise on a restricted budget.

The task facing the group of learners was to present proposals for the way forward in line with the fundamental principles of ecotourism, yet practically addressing the multi-facetted problems surrounding the reserve, under the topics of:

1. Fauna and flora,
2. Activities for the ecotourist,
3. Culture and community,
4. Accommodation, infrastructure, and facilities.

The field work

The students enjoyed the experience immensely and were highly motivated. They visited the natural and cultural resources, and were physically stimulated as they walked, swam in the oceans, rivers and rock pools, explored, and viewed game. For some it was their first experience of the sea. The group became acutely aware, first-hand, of the sensitive nature of ecotourism requirements as they viewed the natural features and took part in ecotourist activities (existing and proposed) - riding horses, paddling canoes; hiking; game viewing, bird watching, and spotting rare plant species. They clambered up to an elevated cliff-face cave, explored the shipwreck, visited historical mission churches, and scrambled around waterfalls. They also tackled what is known in the jargon as *adventure tourism* - risk-activities such as cliff-jumping and swimming out to an island. Some tobogganed down a 60º sand dune, but won't tell that to ecotourist purists. There wasn't time to go fishing.

Real-world status

The students had initially expected the field trip and associated projects to be academic exercises only. However, provincial nature conservation authorities viewed them with credibility. The reserve manager addressed them, explaining the background of the reserve and its rich heritage, as well as the problems facing it. An environmental education officer guided the class to ecological high points, an official took them on a tour of the facilities, and in small groups, they boated up the Msikaba River to the Mkambati Palms.

The regional director of nature conservation came from his head office inland to stay at the reserve and interact with the students, sharing experiences and viewpoints and discussing issues. He took them to lesser-known parts of the reserve and across the river boundary to meet operators of a successful community-based ecotourism venture running on neighbouring tribal land. Explaining that the provincial budget no longer allocates funds for research, and that the state is taking a reduced role in conservation, the director pointed out the current importance attached to research done by universities. Postgraduate programs and theses that address basic research and *ad hoc* topical issues are welcomed.

The reserve and current events in the surrounding regions were topical and newsworthy at the time. The Ecotourism field work coincided with a visit to the reserve by a television producer, who recorded the students' activities and interviewed them for national TV and radio programmes. This interest in their investigation and recommendations further enhanced the experience for the learners.

Exposure to the options ...

In the same way as academic input is required from tertiary institutions, investment input is required from the private sector. Public-private partnerships are viewed as the way forward to ensure that nature reserves remain viable, i.e. a joint approach to resource management. A few months prior to the students' visit, national government had examined development proposals, short-listed certain submissions, and awarded an external tender for the tourism and accommodation facilities. Anticipating privatization to be imminent, structural facilities had been permitted to slide into disrepair, although the accommodation was, in general, attractively furnished. Then tensions arose between the local community and the successful bidding company which, together with other exacerbating circumstances, resulted in the private company to which the tender had been awarded, withdrawing. So the *status quo* continued, on a low budget and with all functions remaining under control of the provincial nature conservation department.

An alternative approach was implemented on nearby tribal land, where a pilot-project for community-based ecotourism had been launched. The group visited this venture, and were addressed by the coordinator of the non-governmental organization (NGO) assisting the community. He believed that the national plan for an SDI (strategic development initiative) in this under-developed area was too grandiose, and suggested that small-scale community-based projects are preferable, along with local community enforcement of conservation legislation. Partnerships and co-operation agreements should ensure that projects survive and communities benefit. Self-employment, with locals taking responsibility for generating income by satisfying particular niche-markets, was a better option than large-scale resort-type developments. The forms of entrepreneurship envisaged were nature-, culture- and adventure-based. All were low-impact and sustainable. A local tribal stakeholder also spoke to the students - his excitement and enthusiasm for the venture clearly evident.

Reports, recommendations and guidelines ...

The students were thus exposed to different models and options, as well as many perspectives on the problem. They came to the opinion that the successful tender for privatisation (the one subsequently withdrawn) had not been in line with the true ecotourism, and were relieved that it was unlikely to materialize. The breakdown in negotiations, however, plunged the reserve's future into even greater uncertainty. The community issue remained complex, as locals complained that the reserve had the best land (a factor due to sound land-management policies). Another unresolved matter was identifying which local dwellers actually comprised the community, since villages as far away as 50 kilometres were anticipating benefits.

Against this background, the four groups commenced work on their research and recommendations. They had seen maps and a slide show in class before departure but, on-site, the natural environment and the complexity of the situation came to life. In the evenings groups met to discuss their approach. Resources were consulted, and out came the laptop computers. One group held a prolonged 'meeting' on the 12-hour journey back home. Once in Pretoria the task of negotiation and writing-up continued. Two months later reports containing proposals were submitted to the course lecturers, marked up, and returned to the students for further work. Usually, academic products are assessed, a mark is given, and the matter ends. However, nature conservation authorities had requested copies of the reports and guidelines, so they were extended and refined to a standard beyond the norm for student projects. The facilitator integrated the documents, adapted the styles to a consistent format, and incorporated further illustrations. The consolidated report was then presented to the authorities.

The Mkambati project was a stimulating, yet demanding, real-life experience for all concerned. The study was featured in two national television programmes, one of them centred around the students' investigation. At the end of the academic year, the class held a final meeting to watch a video of the TV programme. On this occasion the researchers' questionnaires were distributed and completed by all present. Others were distributed to those who had not been present. The survey therefore included all twelve student-participants, as well as an interview with the facilitator.

Figure 5C.2 is a map of the Mkambati Nature Reserve (Queiros, 2000b), indicating the main features. The map is followed by Figure 5C.3, which is a photo-spread to set the scene.

Figure 5C.2 Map of Mkambati Nature Reserve (Queiros, 2000b)

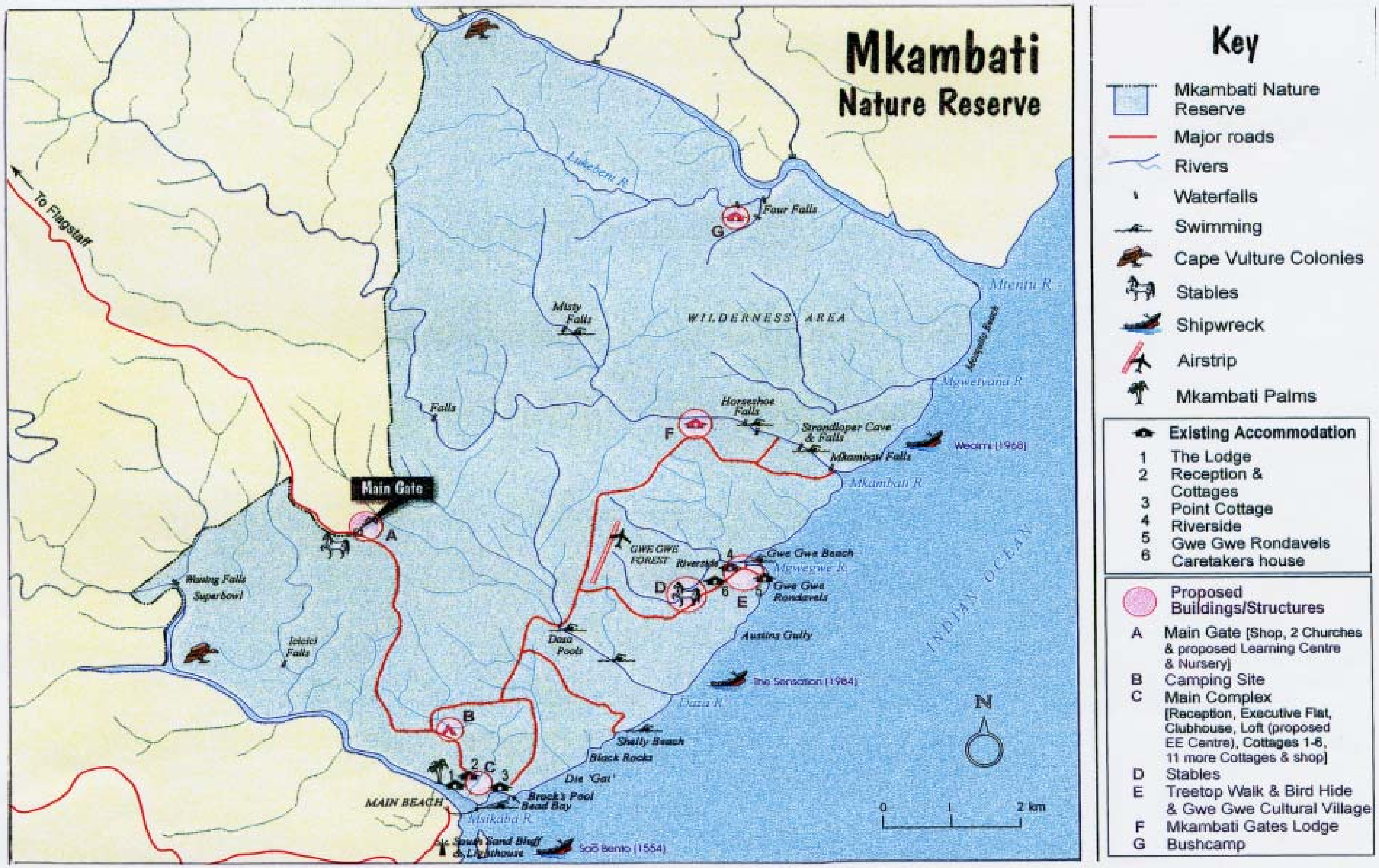


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Figure 5C.3 Setting the scene

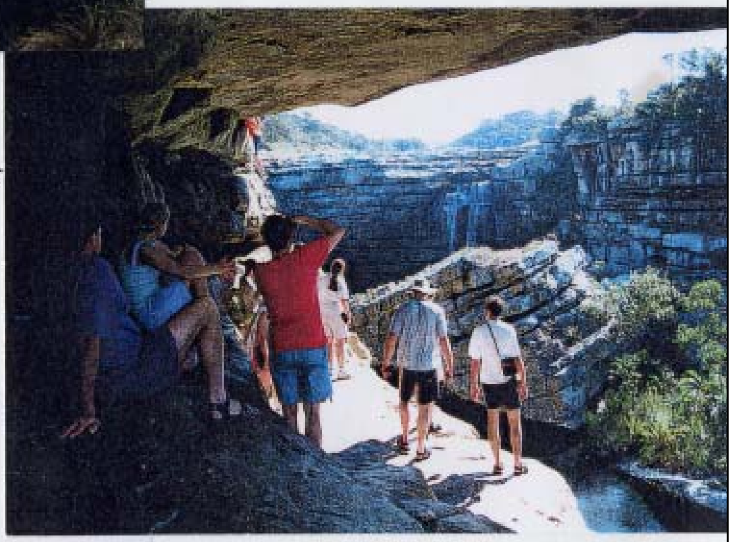
Problems of the paradise that is Mkambati Nature Reserve: How both to promote viable, sustainable ecotourism and preserve a fragile environment?

Several factors make Mkabati unique ...

Mkambati palm, *Jubaeopsis Caffra*, with its small coconut-type fruit is unique to the reserve, which is named after it. This tree is found nowhere else in the world.

Cape Vultures *Gyps Coprotheres* nest and breed on the tall cliffs of the Msikaba Gorge.

Management wrestles with the issue of Mkambati's carrying capacity - how many tourists should see this – and how close should they get?



Students investigate the Strandloper Cave high on a cliff face - with a view onto the Strandloper Falls and a huge natural rock pool, and debate the dilemma of how best to promote and yet preserve this natural and cultural heritage. Note: *Strandlopers* were seashore cavemen.

When game viewing in a Land Rover late in the afternoon, the best view is from up top.

Where should vehicles be permitted - and where only hikers? What sort of roads? What about mountain bikes? These were some of the issues for which students suggested guidelines.

5C.1.5 Research design of the Mkambati case study

Within an overall approach of *action research*, as outlined in Chapter One, Section 1.5, qualitative and quantitative research methods are combined in this case study.

The descriptive data in the six 'Initial discussion' subsections: 5C.2.1.1, 5C.2.2.1, 5C.2.3.1, 5C.2.4.1, 5C.2.5.1, and 5C.2.6.1, is generated by *qualitative ethnographic research*. The researcher participated personally in the field trip, obtaining rich *observational data* on-site, observing activities and informally interviewing learners and facilitators.

The information in the six brief subsections with the 'Viewpoint of the instructor-designer': 5C.2.1.2, 5C.2.2.2, 5C.2.3.2, 5C.2.4.2, 5C.2.5.2, and 5C.2.6.2, was also obtained by the researcher *interviewing* the lecturer/facilitator after completion of the project, to obtain her insights and in-depth understanding of the situation.

The primary data collection method for the third set of subsections, 'Findings from the learner-survey': 5C.2.1.3, 5C.2.2.3, 5C.2.3.3, 5C.2.4.3, 5C.2.5.3, and 5C.2.6.3, was a *qualitative* and *quantitative, empirical,* but *non-experimental, survey*. The researcher conducted a *questionnaire* survey with the group in its entirety, i.e. with all twelve participants. The survey was focused on the underlying learning theories and characteristics of the project. The questionnaire, as a whole, is available in Appendix C, and questions are also shown in appropriate subsections within the text. The data in Section 5C is not statistically analyzed, since this would be an inappropriate way to deal with rich descriptive data. Nor are percentages shown, due to the small population. Table 5C.1 shows profiles of the learners surveyed.

Table 5C.1 Profiles of the learner population surveyed
(n = 12)

Characteristic	Subdivision	
Gender	Female 5	Male 7
Full-time / part-time	Full-time 10	Part-time 4
Prior qualifications	3rd-level bachelors degrees 8	Honours/ 4th-level degrees 4
Ethnicity	White 9	Black 3

5C.2 Investigating Mkambati 2000 - using the Hexa-C Metamodel

The practical fieldwork project is investigated with respect to application of learning and instructional theory, using the HCMm framework as a tool.

Sections 5A and 5B, related to the FRAMES and RBO case studies respectively, were structured by first examining conformance to the more theoretical elements of the HCMm, and then paying attention to the HCMm aspects that relate to its practical features and characteristics. For the Ecotourism project, the sequence of these aspects is reversed - addressing first the three practical characteristics (creativity, collaborative learning, customization) and then the three theoretical approaches (components, cognitive learning, constructivism) underlying the type of instruction and learning. Investigating creativity and motivation first, helps to portray the circumstances and to set the scene for the subsequent sections.

5C.2.1 Creativity

In examining creativity and motivation within a learning environment or event, one would look for aspects such as Dick's (1995) conditions for creative instruction. Several of these are explicitly-designed features, not relevant to a field trip or project. Features appropriate to investigate in the Ecotourism project are the matching of learner-interests, motivation in the learning event, and innovative aspects of the event. In an instructional context, creativity is strongly connected to motivation - engaging and engrossing learners, and also to affective aspects - the emotions/attitudes/values of learners as they continue in a learning experience. The discussion subsection and the facilitator's viewpoint address motivation and learner-attitudes, while the learner survey investigates both motivation and innovation.

5C.2.1.1 Initial discussion

The students were highly motivated by their experiences on the field trip. As mentioned in the text box, they participated in stimulating activities and became acutely aware of the sensitive nature of ecotourism. They realized that their combined expertise could be used to the benefit of all stakeholders and could impact on all the elements of the ecotourism tetrahedron. They could:

- contribute to the preservation of fragile, pristine topography;
- make a difference to quality of life for local communities;
- strive to balance the delicate divide by suggesting an approach for the tourism industry that would realize returns, retain harmony with the natural environment, and be acceptable to the local community; and
- develop rewarding participatory experiences for local and international ecotourists.

Intrinsic motivation due to real-world worth

They had viewed the project as an academic exercise, and were pleasantly surprised to find that the authorities held them in high regard and keenly anticipated their findings. Their proposals would be studied by the region's future decision-makers. This factor generated a **high level of intrinsic motivation** among the students. They had not expected to practice the art of reflective, respected practitioners until they were mature professionals (Schön, 1987). The television and radio programmes featuring clips of their activities and investigation were further motivations.

The project was not a real-world simulation - it was real-world, real-life!

5C.2.1.2 Viewpoint of the instructor-designer

> The students were highly motivated – personal involvement and actually being in the reserve made them passionate about the area. This increased as they saw more of it. The importance then of writing the right proposal for the reserve became important to them personally. They wanted to see the place developed correctly. Definitely an *emotive* experience which influenced their learning, and their desired outcomes. The passion of the students reflected an intrinsic motivation - that this was important to them personally.
>
> Evening discussions were also very lively with vigorous debate - I think these sessions encouraged learning as the students really had to understand complex issues and grasp all the inter-related variables. They had to interpret the dynamics of the situation and decide on their own beliefs.
>
> They were excited about the task and completely engrossed in it.

5C.2.1.3 Findings from survey of the learners

The survey incorporated several questions on the aspects of motivation, creativity and innovation. There was no prompting and the considered responses were spontaneous:

3.1 What motivated you in this learning experience?

3.2 The requirements in this project were innovative and non-conventional.
Describe what you experienced as innovative, and how you feel about the approach.

3.3 How did you feel about this project and the problem-solving approach?

For example, did it engross you, hold your attention, stimulate you,
or did it frustrate you, bore you, cause you to lose interest, etc?
Answer for: before the trip / at the nature reserve / during write-up time afterwards.

Responding to Questions 3.1 and 3.2 on motivation and innovation, several students dealt with the real-world nature of the problem. Tables 5C.2 and 5C.3 set out their views and comments on motivation, creativity and innovation in the learning experience.

<table>
<tr><th colspan="2">Table 5C.2
What motivated you in this experience?</th><th colspan="2">No of students (n = 12)</th></tr>
<tr><td>Possibility of recommendations being used</td><td>Our input might actually be used / market-oriented exercise / social and economic benefits for stakeholders / chance of influencing future developments / solve a real-world problem / management took us seriously</td><td colspan="2">8</td></tr>
<tr><td rowspan="4">The natural environment</td><td>Potential as an ecotourism destination</td><td>3</td><td rowspan="4">7</td></tr>
<tr><td>Crossing the river and experiencing the community where ecotourism was a reality</td><td>1</td></tr>
<tr><td>Unique beauty / desire to maintain pristine surroundings</td><td>2</td></tr>
<tr><td>Seeing the sea and swimming in it!</td><td>1</td></tr>
<tr><td rowspan="2">Academic motivations</td><td>At the end I was motivated to finish because of my other academic work pending</td><td>1</td><td rowspan="2">2</td></tr>
<tr><td>Prospect of high quality product, good marks, bursaries, co-authoring a publication</td><td>1</td></tr>
</table>

<table>
<tr><th colspan="2">Table 5C.3
What did you find innovative in this approach?</th><th colspan="2">No of students (n = 12)</th></tr>
<tr><td rowspan="2">Nature of the Project</td><td>Kind of problem we will encounter in a country in a situation of transformation / tourism from ecotourism perspective /
Marketing - not just tourism, but marketing an ecotourist destination</td><td>3</td><td rowspan="2">5</td></tr>
<tr><td>Real project / might be used / practical value / final product was a quality, consultant-type document</td><td>2</td></tr>
<tr><td rowspan="2">Nature of the learning</td><td>The way we had to think / integrate / use an open-minded approach / personal experience of the problem - not just a given scenario</td><td>5</td><td rowspan="2">7</td></tr>
<tr><td>Discussion and debate between class members</td><td>2</td></tr>
<tr><td colspan="2">Helped us to be innovative ourselves / think laterally</td><td colspan="2">4</td></tr>
</table>

In the open-ended responses, most gave more than one motivation. As well as appreciating a real opportunity to put theory into practice, they were impressed by the natural surroundings and their potential:

- ***Inspired by the natural environment***
  The opportunity to present such a unique destination to others. /
  The reserve itself - one of the most beautiful places on earth. / An adventure and a challenge ...
- ***Own creativity fostered by a novel experience***
  The chance to use my theoretical knowledge in combination with creative faculties to try and solve real-world problems. / I learned to think creatively to solve a real-world problem. /
  The solutions we postulated as feasible tourism guidelines were innovative ideas. /
  We used our past experience as well as the authentic thinking stimulated by the experience.
- ***Strategic exploration of errors - self-regulation and metacognitive adjustments***
  It was a novel experience learning how to combine one's own knowledge and interest with the subject of the group one worked in. It allowed us to experiment with our ideas, <u>which were not always correct</u>.

Only one comment (Table 5C.1) dealt with the extrinsic motivation of a high grade. Most were intrinsically motivated by the value of the experience and the chance to make input into a real-life situation. The upcoming subsection 5C.2.3.1 on customization of the experience, will refer to students 'passionate' about a cause - a factor which induces high motivation.

- ***Intrinsic motivation***
  I found it innovative to do a project which would be of practical use. Students' practical work usually retains an element of amateurism and adds little value to the organisation. Developing a market-style presentation was also unusual for most of the students. We could have simply presented an academic treatise (which is what the first draft looked like), but we reworked it to produce a final report which was a quality consultant-type document.

Motivation changed over the duration of the project, fluctuating from the initial high during the actual field trip. The responses to Question 3.3 showed common emotions **prior to the field trip** (not tabulated), namely, keen anticipation and excitement, with only one student feeling unmotivated, considering it just another subject. **During the trip**, the affective-cognitive connection was firmly in place, inspiring the students to address the issues. They all experienced positive emotions, categorized in Table 5C.4.

Table 5C.4 **Emotions at the nature reserve during the project**	**No of students (n = 12)**
Stimulated / engrossed / captivated by scenery / An adventure! / It changed my attitude - I want to develop beautiful places in a sustainable way in future	8
Interested / enjoyed it / informative	3
New comprehension – it bridged the gap between class knowledge and a real-world situation / theory-practice	2
Flabbergasted by complexities / Frustrated by problems	2

A representative, all-encompassing comment was:

> *A well structured experience - ample opportunity for absorbing the essence of the reserve, as well as time for discussion and reflection. I felt interested and engrossed at all times.*

During write-up time afterwards, conflicting emotions emerged. No longer experiencing the stimulating atmosphere of Mkambati, learners' motivation decreased. They were equally divided between those whose attitude remained positive and those who tended to the negative. Table 5C.5 lists the emotions in decreasing order of satisfaction:

<table>
<tr><th colspan="2">Table 5C.5
Motivation at write-up time</th><th colspan="2">No of students
(n = 12)</th></tr>
<tr><td rowspan="3">Positive</td><td>Challenging / rewarding / visionary</td><td>4</td><td rowspan="3">6</td></tr>
<tr><td>Did not find it difficult</td><td>1</td></tr>
<tr><td>Frustrating, but rewarding when finished</td><td>1</td></tr>
<tr><td rowspan="3">Negative</td><td>Struggled to find answers from the theory that would solve the complexities</td><td>1</td><td rowspan="3">6</td></tr>
<tr><td>Initially challenged, then bored</td><td>1</td></tr>
<tr><td>Frustrated / took too long / difficult to fit it in with other obligations</td><td>4</td></tr>
</table>

The process of writing the reports and recommendations was a major task, carrying heavy responsibility due to the possibility of implementation. In the opinion of a mature learner who was an experienced professional:

> *It was a challenge to write up the guidelines in a way that was realistic and meaningful, but it was a positive experience to apply theories practically in a real life situation.*

5C.2.1.4 Concluding discussion

The aspect of creativity that emerges most strongly from this survey data, is the students' motivation and enthusiasm, motivation engendered by the perceived worth of the experience and the value of being able to play a real-world role. The lecturer's belief that personal involvement in the problem situation made learners passionate about doing their task well, was borne out by the findings.

The investigation showed that not all students maintained their initial high motivation. For about half of them, it waned towards the end, as the extent of preparing reports for submission to the authorities - involving more commitment and refinement than the normal academic activity - impacted on other obligations. Students frequently handle deadlines under pressure by submitting lower-quality deliverables (and obtaining lower grades), but that could not be done in this case. Thus the very factor that caused high motivation during the field part of the trip, i.e. the real-world nature of the project, was perceived as an obstacle during the report-writing period.

Deadlines and high quality are part of real-world pressure. However in the real-world, there is a major motivating incentive, which did not accrue to the students - the prospect of remuneration for services rendered! However, real-world learning experiences cannot exact real-world deliverables without offering some personal benefits. Case Study Two showed how RBO also exacted real-world products, but in several cases with a tangible benefit, in that students developed artefacts they could use in their professions to simplify duties or enhance their work. In the case of the Mkambati Project, the benefit was gaining expertise that had a career value.

The perceived worth of the experience was high. The facilitator's desire to present an innovative project with all the dynamics, variables, and complexities of the real world was achieved. No mere academic exercise could have resulted in the same level of learning or prepared the class better for the realities of consulting in the workplace.

5C.2.2 Collaborative learning

In Section 2.5.1 the difference was explained between collaborative and co-operative learning. This section investigates the use of both in the Ecotourism project, as the class was structured into a group of groups with separate but related aims. Johnson and Johnson's (1991) key elements of co-operation are used to structure part of the evaluation in 5C.2.2.3.

5C.2.2.1 Initial discussion

As previously stated, the students worked in four groups of three, the topics being:
fauna & flora; ecotourist activities; culture & community; and accommodation &facilities.

Each group undertook its own study. Researching and writing up each topic involved expert knowledge of the domain, analysis, and a comprehensive written report with suggested guidelines. The format and presentation had to such that the four reports could be integrated into a single document compiled by the facilitator, an aspect which she mentions in 5C.2.2.2.

- ***Collaborative and co-operative learning***

The overall exercise could be described as *meta-collaboration* - a group of groups - since the four projects had to interrelate in a consistent way, so as to be compiled into a single integrated, holistic document for submission to the authorities. It can also be viewed as an integration of collaboration and co-operation, in that the small groups worked *co-operatively* to achieve a single aim and generate a single product, using each member's capabilities to complement one another.

5C.2.2.2 Viewpoint of the instructor-designer

Students had to work in four collaborative groups. I suggested the four topics and they chose the group of their preference, the only condition was that there had to be three in each group.

I think the fact that it was such a prolonged, intensive project was a challenge to them in terms of group learning - a short team project is easy! In a long one, your powers of negotiation and feeling comfortable in a team are tested. One group requested that I include a team peer-evaluation (to affect the final mark) because they felt that a member was not playing his/her part. I would do this in future, but couldn't change the system at that stage. As the lecturer, I did not pick up problems in the other groups, but there may have been issues of which I was not aware .... perhaps responses to the questionnaires will indicate this.

Another challenge was having four groups, but yet aiming to generate a unified report in which each group's work complemented the other groups' and did not contradict anything. We started shaping each sub-project **as part of an overall group**, and trying to maintain linkage.

5C.2.2.3 Findings from survey of the learners

Open-ended questions determined the learners' impressions of their collaborative work:

5.1	How did you experience the teamwork in this problem-based learning? Please elaborate.
5.2	What is your opinion about joint accountability and a team mark?

The responses to Question 5.1 were mainly positive, as learners recognized the worth of integrating diverse disciplines and skills within a context of teamwork. Their spontaneous comments are classified under some of the key elements of co-operative learning (see 2.5.1.2).

- ***Empowerment of individual learners***

... unique, because we came from very different backgrounds, and classmates contributed to broadening our view of the situation. /
We delegated tasks, then peer-reviewed our performance in brainstorm sessions. /
We had good discussions and debate ...

- **Positive interdependence**

They realized the responsibility that comes with teamwork, acknowledging that individual efforts affect group-performance, that schedules must coincide, and that some team members carry a greater load:

It makes you work harder, because what you do affects others. /
Our deadlines were met and each recommendation was a product of three minds. /
We could each do something we are good at!

I grew up in a culture that emphasizes individualistic learning and achievement. This contradicts the spirit of teamwork. But I understand and really appreciate the value of groupwork. The experience allows learners active involvement. They could be creative and it culminated in multifarious ideas, contributed by students of diverse cultural backgrounds.

- **Positive interdependence** *(continued from previous page)*
  Non-performance by one can jeopardize overall quality. /
  I struggle with time management and operate by crisis management, so I probably don't give my best, which might have been a bit tough on my team. /
  In any team some pull their weight more than others.

In response to Question 5.2, there were strong reservations regarding joint accountability and team marks:

- ***Joint accountability***
  Joint accountability works when team members have authority to hold others accountable. As students at the same level, none of us had that authority.
  Peer-review would help - marking others on participation and input, as a contribution to the final mark. /
  I strongly disagree with a joint mark!

  Some, clearly achievement-oriented, prefer working alone. For example:
  Joint accountability sometimes gets in the way of personal ownership.

The students' opinions on collaborative learning are quantified and integrated in Table 5C.6, showing that eight of the twelve perceived the benefit of collaborative work. However, from the reservations in three of the rows, it is clear that collaboration was not problem-free. In particular, six students pointed out that not all participants put in equal efforts.

Table 5C.6 **Views on collaborative learning**		**Number of students (n = 12)**
Collaborative work is good / helpful / constructive		8
Integration of different ideas	Positive: value of integrated ideas	4
	Negative: difficult to integrate the contributions / I prefer to work alone	4
Joint accountability	Positive: the responsibility makes you work harder	3
	Negative: some put in more effort than others	6
	You need a good, enthusiastic leader	2
Ran out of enthusiasm at the end / Just wanted to get finished		2

Positive remedial suggestions were made by an experienced adult learner:

It would be useful if in the planning stages, groups are encouraged by the lecturer to discuss how they will work together and set norms - perhaps guidelines such as:

- *How do we want to work together?*
- *What do we do if someone does not work to the deadlines?*
- *What kind of standards are we setting as a group?*

University teamwork is a way of preparing the learner for work in the real world. However in the real world, there is always an appointed team/project leader responsible for holding and pulling things together - and holding others accountable. Other team members have contractual obligations, which - if they do not meet on time and to quality - could cost them their jobs. No student has this sort of authority over another.

Finally, there were impromptu comments relating to meta-collaboration - the group-of-groups. An interesting point made by a learner with a multi-disciplinary background, was that she would have liked an opportunity to give input to other groups as well - she felt restricted by confinement to one. Also in reference to meta-collaboration, another learner advocated pertinently:

> *I would have liked to be more aware of the work of the other groups. We should possibly have, as a whole class, discussed each section in brainstorming sessions right at the beginning.*

5C.2.2.4 Concluding discussion

The evaluation of collaborative work in the Ecotourism project revealed several complexities. This group work was distinguished from conventional collaborative and co-operative work by its meta-collaborative nature, in that the groups were producing parts of a whole. The facilitator had to view the project holistically and integrate the separate reports/recommendations into a single document, ensuring that proposals and suggestions did not duplicate, infringe upon or contradict others.

This integration and establishment of internal consistency demanded much work on the part of the facilitator, which could have been avoided if tight norms and practices had been set up in advance. On the other hand, a rigid format would have inhibited personal interpretations and complicated the incorporation of specialist material, imposing artificial boundaries at odds with the constructivist nature of the project.

The point was strongly made (six of the class) that not all put in equal efforts. The same matter was raised in RBO (Section 5B), but did not appear to be an issue. Why was it an issue in the Mkambati Project? Probably because team marks were awarded. The more motivated/committed students would not accept lesser efforts on the part of fellow-learners that might impact on their own grades, so they compensated to ensure high quality products. Peer-evaluation and self-evaluation as part of the final mark, with individual grading for each learner, would mitigate against this problem

The nature of the responses shown in this section and others is one of the benefits of qualitative research. A multiple choice questionnaire does not elicit this type of data.

Due to the cross-disciplinary nature of the group, the project capitalized on heterogeneous strengths. Three of the students were already professionals, and the others had a wide variety of knowledge and expertise, although not to the competency level of practicing consultants. Complementary skills, serious efforts and the facilitator's work in preparing the unified document, resulted in an end-product with high utility. The provincial authorities expressed sincere appreciation and placed it on their intranet, stating that it contained aspects which could be implement. The project also achieved its academic ends - due to their extensive and intensive efforts, all four groups earned distinction marks.

5C.2.3 Customization

This section of the evaluation investigates how Mkambati 2000 customized learning to the needs of individuals. Learning is said to be customized when an individual can use a learning event so as to attain effective and meaningful learning, but in a way that is also personally optimal. The project is also examined to investigate learner-centricity.

5C.2.3.1 Initial discussion

In the social- and human sciences there is an occurrence less encountered in other disciplines, namely, certain students who take a direction of study because of a personal passion or sense of mission. In her participation and observation, the researcher noticed how some of the Ecotourism students viewed their studies as more than academic formalities. Being individuals passionate about a cause, they approached the course with a sense of long-term purpose. Some of the issues that evoke strong sentiments are the environment, the development of disadvantaged communities, and public-private partnerships. For such individuals, the Mkambati 2000 Project drew out their best, as they applied their learning and experience to the problem, and made proposals in line with their personal vision and beliefs.

Learning was customized as students found roles within their groups, gaining new learning, but in a way that was also personally meaningful. They used their varied skills - photography, report-writing, proposal formulation, technical computer skills, and most important, their professional expertise in various disciplines. The key factor in customization was the **application of individual diversity**, in a way that brought personal fulfillment.

The photo-spread that follows in Figure 5C.4 shows some of the variety at Mkambati, indicating how different individuals could pursue their specialities. The learners were able to invest their own interests and expertise into the project, within the contexts of the four topics given in Text Box 5C and in Section 5C.2.2.1.

Figure 5C.4 Customizing the project to learners' interests

History and culture: Exploring the wreck:
Which ships - of what nations - were wrecked near Mkambati over the centuries?
Why so many Wild Coast wrecks?
What happened to survivors ...?

Adventure activities: Secret waterfalls in riverine forest, secluded bathing, cliff-jumping, 'kloofing' (canyoning)

Fauna and flora: A novel angle for viewing rare samango monkeys in their forest habitat. Should tourists roam Mkambati freely to savour it? Should there be interpetive trails? Or should these activities be guided tours only ... ?

Zoologists, ecologists and environmental management students ponder the unusual occurrence of a large herd ofeland silhouetted against the ocean. Is Mkambati over-stocked? If so, what alternatives can address the matter? The carrying capacity issue relates to game as well as to tourists.

5C.2.3.2 Viewpoint of the instructor-designer

The learners could personalize the project to use their own expertise and skills. It was their prerogative - with guidance from the lecturers - to decide on the sources used in their research, the content of their projects, and the guidelines they suggested regarding the way forward for Mkambati.

We did have problems with the negotiated goals. Students did not realise that, after handing in the first draft, they would be required to do so much more work on it. I thought that had been communicated, but it appeared that they were tired of the thing by then, and just wanted to finish at the point they chose - like students normally do! To them it seemed like lecturer-control, not learner-control, but we had to improve the products for real-world presentation. The bonus was, of course, was that the extra work gave them higher marks.

5C.2.3.3 Findings from survey of the learners

The following questions surveyed the extent of customized learning, investigating how the learning experience matched students' preferences and how they could personalise the problem-solving to their own style and expertise:

4.1	What are your personal learning preferences? In what way did this experience match / mismatch these experiences?
4.2	Were you able to personalise this problem-based learning to your own particular style, needs, passions, expertise, etc.? Please elaborate.
4.3	Which computer systems did you use?
4.4	Did you experience the project as learner-centered? Please explain.

All except one responded that they had been able to personalise the learning experience to their own requirements. Table 5C.7 sets out elaborations of responses to Questions 4.1 and 4.2, indicating that students particularly enjoyed the opportunities of contributing their personal ideas to the debate and pursuing them as the reports and recommendations developed. Another major factor in satisfying learning preferences was the chance to slot into a group that approached their own subject/discipline within the context of ecotourism.

Table 5C.7 **Views on learning preferences and personalisation of the project to own style, interests, and expertise**	**Number of students (n = 12)**
Hands-on practical / apply theory to practice	4
Opportunity to contribute own ideas / personal interpretation / work in my own way / freedom to express opinion / <u>we</u> decided on content	7
Enjoy discussion / brainstorming / interaction / negotiation	4
Could use my subject-matter expertise / Chose a group that interested me	6

The students also raised other pertinent issues:

- ***Preparation for the future:***
  The personal consultations, e.g. with management, were good training for what will be required in employment. /
  To do something real - that people could use - it was an opportunity to make a contribution. /
  We had to do our <u>*own*</u> *research - we really did learn.*

- ***Real-world problem-solving:***
  It was an opportunity for logical, deductive problem-solving after reviewing all aspects and pros and cons of the situation. /
  We were exposed to what really happens and contrasting it with what could happen.
  (Note: the above refers to the difference between reality and the textbook model.)

  I have empathy with disadvantaged communities and have done volunteer student work, but this is a real chance to make a difference and contribute to upliftment and a work ethic.
  (This is a comment made during the reseacher's personal discussions with a learner.)

- ***Facing real-world complexities***
  Students in the group that investigated culture and community admitted they had struggled - their topic was a complex issue in uncharted, controversial territory.

When asked in Question 4.4 whether they experienced the project as learner-centred, ten replied in the affirmative. Of the two who disagreed, one interpreted the question in a positive light:

It was problem-centered; our part was to solve it.

The other expressed a major reservation:

I felt that we were 'used'.

This section (Question 4.3) also investigates the computer packages used as tools. Table 5C.8 presents the findings. Bearing in mind that the teamwork capitalized on delegation and strengths, it is likely that the four who used graphics, represent all four teams. The different kinds of software used indicate individual preferences and strengths, for example, one of the spreadsheet users was the student who made the observation regarding 'logical, deductive problem-solving'.

Table 5C.8
Software packages used in generating collaborative projects

Word processor	Database	Spread-sheet	E-mail	World Wide Web	Graphics Packages	Other (specify)
10	2	2	7	9	4	-

5C.2.3.4 Concluding discussion

The type of customization applied in the Ecotourism project is different from the traditional views of customized learning. Learning was customized:

- Not by using a customizable computer system;
- Not by doing own choice of activities - own sequence, quantity, content, mode, etc (as in FRAMES);
- Not by customizing a generic task to develop a product in line with their interests (as in RBO); but
  - by learners finding their role in the group - using their specialized expertise to tackle defined goals and develop stated products within a team context, each contributing to the product by using what he/she knew best.

Although the Ecotourism students had to grasp the complexities of the problem in hand, they did not experience the same learning-gap or stress as some of the RBO learners, who had to learn new skills and concepts before they could make progress. The class was eager and able to build on their prior learning and on their new knowledge of ecotourism, as they set out to propose solutions. Furthermore, the learning event provided an opportunity to build on value systems and indulge personal passions. This contributes both to intrinsic motivation and to customization of the experience, and holds great real-world value and future career benefits.

Using a botanical analogy, a learner suggested that the project was 'mutualistic', meaning that, on the one hand, the problem provided the students with a practical learning experience, and on the other, the results were useful for management at the reserve.

Once again, an inter-relationship between learning theories was in evidence. The customization that occurred in the project - allowing each learner to contribute what they knew best from their former specialities - could not have happened outside of collaborative work.

5C.2.4 Components

The Ecotourism project itself incorporated no explicit teaching of basic theory, only practice, since the field trip and subsequent write-up were viewed as practical application of prior learning. The knowledge acquisition process of the underlying theory is outside the scope of the learning event (although within the scope of the Ecotourism course as such). There was no basic instruction along the lines of Merril's (1983) CDT, since it was assumed that basic skill- and knowledge components were in place as existing foundations. This section, therefore, only briefly examines the nature of the basic knowledge and the way in which it was communicated.

5C.2.4.1 Initial discussion

Mkambati 2000 involved three kinds of knowledge. Students came into the project with two of them, and acquired the third during the field experience:

(i) Pre-existing specializations, related to their various former degrees;

(ii) knowledge of ecotourism; and

(iii) awareness and understanding of the particular problem.

In the first and second fields, basic components of learning preceded the field trip, and are outside the scope of the project and questionnaire. Ecotourism theory and the practice of Ecotourism were taught during class lectures and discussions before the trip.

Before the project students were given basic material about the reserve, and were required to research their own angles. They took their class notes and their own research material on the field trip, and were therefore equipped both with the rudiments of ecotourism and the subject-specific theory and practice of their own areas of specialization. The kind of learning actually experienced on the project was holistic and circumstantial. The students had to absorb and assimilate various issues, an integration of material that cannot be viewed as transmission of components.

5C.2.4.2 Viewpoint of the instructor-designer

> The basic building blocks of the ecotourism discipline, as communicated in the fourteen weeks of class-learning, are multi-disciplinary, requiring much integration.
>
> In order to go on the trip, class attendance was vital. Each student had a chance to present a section of the course and hand it to their fellow students a week before presenting, allowing time for the fellow-students to peruse the document and prepare questions. Whether they actually do that is not always clear! We also had guest lecturers; one in particular is an expert in the practical implementation of ecotourism, and he set out the main practical principles.

5C.2.4.3 Findings from survey of the learners

N/A - no survey questions related to component-based instruction.

5C.2.4.4 Concluding discussion

No explicit knowledge or skills components were communicated during the field trip or write-up, since these had been presented in the prior class-learning sessions, often by learners themselves. Mkambati 2000 presented an opportunity to contextualize and consolidate prior knowledge.

5C.2.5 Cognitive learning theory

An investigation of cognitive learning should examine how new knowledge is integrated with prior learning, how learning gaps are bridged, how learners handle planning and self-regulating, and develop critical thinking skills. This section also examines the application of cognitive flexibility theory (Spiro, Feltovitch and Coulson, 1994) and the cognitive-affective connection (Tennyson & Nielsen, 1998) in the Mkambati learning event.

5C.2.5.1 Initial discussion

As pointed out in Section 5C2.4 on components, there was no explicit teaching during the actual project and fieldwork period; rather, there was hands-on experiential learning. There was also intensive interaction with the resource base (the natural and cultural environment) and with stakeholders, which stimulated cognitive processing and critical, creative thinking.

- ***Active planning, participation and self-regulating***

The students were actively involved in researching their topics and generating deliverables, although guidance was available from the facilitator as required. Each group embarked on extensive literature/resource surveys, including documents and previous research specifically on Mkambati. They were responsible for their own progress, and different groups progressed at different rates.

- ***Integration of new with prior knowledge / mental schemata***

New knowledge relates to prior learning in different ways. Sometimes advanced knowledge builds on basic knowledge in the same domain, and sometimes it entails completely new subject matter in a different domain, but associated with the prior learning. The Mkambati project involved both types:

- As individuals, some of the students could apply their own personal discipline directly to their group topic, giving their specialized expertise to the multi-disciplinary challenge, but also gaining new and broader contextualized knowledge in that domain on a just-in-time basis.
- As a group, they learned new Ecotourism concepts, and applied their varied former learning, reorganizing and integrating internal knowledge structures.

- ***Cognitive flexibility theory***

Cognitive flexibility theory (2.3.4.4 and 2.4.5.2; Spiro, Feltovitch & Coulson, 1994) is a cognitive-constructivist approach concerned more with the assembly of mental schemata than their retrieval. Flexibility theory emphasizes transfer of knowledge and skills beyond the initial learning situation, using information from multiple perspectives and case studies to present varying examples. It supports the use of interactive technology, and has primarily been applied in history, biology, and medicine. The Mkambati learning event satisfies the main principles of cognitive flexibility theory:

1. Students were exposed to *multiple representations* of content in their learning activities as they used varied sources of information and guidance: class notes and lecturers' expertise, libraries, web-searches, and talks by / interviews with stakeholders in the nature reserve. They also encountered an excellent case study on their visit to the bushcamp and community ecotourism venture just outside the reserve border.
2. The content domain with its complexities and controversies was *not over-simplified***.**
3. Class lectures prior to the field trip had set the context by incorporating *case-based studies* in general and, in particular, by holding a slide show of the reserve and distributing introductory maps and documents.

5C.2.5.2 Viewpoint of the instructor-designer

The experience required in-depth planning by learners of their team project - setting goals and deadlines, being in charge of something that had to be good, because it was to be a real-life submission. Feedback was given to students on their first versions, and then they were sent back to work on it again on their own. This required self-discipline and time-management, skills that are frequently under-developed in students.

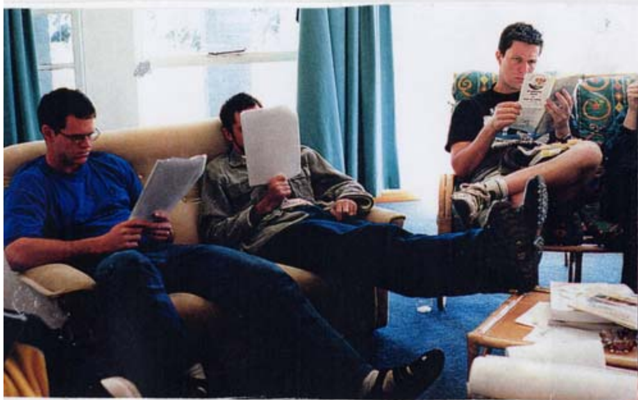
The key to the project was integration, both in terms of:

- Integrating a wide variety of study fields/topics - the enormous scope of ecotourism in practice was confusing for them at first - combining ecotourism issues of history, anthropology (tribal culture), zoology, botany, architecture, geography, ecology, sustainable development, etc. with their prior knowledge, when each of them had expertise in some field/s, but little knowledge in others, and most of them were not yet experts in any one of the fields; and
- Integrating what was learnt in class and in other courses with what had to be done in practice. I think they struggled at first to put theory into practice in the on-the-ground Mkambati situation, but later became more comfortable with the process.

Two of the pictures in the next photo-spread, Figure 5C.5, show how we spent the evenings. After thought-provoking sessions of information, briefings and discussion, they would settle down to serious work, relating their own knowledge to the specifics of the problem on hand. In the first day or so, they mainly read and worked alone, studying documents on Mkambati and the ecology of the region. Then – more and more – they worked in their groups, as they converted their knowledge and reasoning into meaningful contributions.

The task called for planning, communication and articulation of ideas. But more than just communicating with their teammates, some students had the chance to communicate nationally as they were interviewed for a TV program on the Mkambati Project and the issues it addressed.

Figure 5C.5 Integration and issues



Integration: Out come the maps, articles, and previous proposals for Mkambati, etc. Out come notes, and jottings made while listening to stakeholders.
Read and ponder – integrate and assimilate - then jointly make proposals and suggest guidelines.

Issues: Pause a while and consult the charts on the wall. Wrestle with the issues – which compromises are pragmatic and which are risky?

Issues:
Students interviewed for national television:
'What is your opinion on the way forward?'
'What kind of accommodation …
How appropriate is the house behind?'

After wrestling – resolution ?
Not quite. Satisfied with fieldwork well done, the group paused and posed for the traditional photo. But frustration still lay ahead ...
Tough decisions had to be made, group consensus achieved, all contributions had to be forthcoming, then worked into a single coherent, cohesive, consistent document of ecotourism guidelines.

5C.2.5.3 Findings from survey of the learners

Several questions investigated how cognitive learning occurred during the project.

2.1	Describe how the knowledge and skills required of you in the project related to your own prior learning (i.e. what you know from previous study).
2.2	In situations where you lacked prior knowledge, how did you bridge the gap?
2.3	Problem-based learning is open-ended. It has no fixed ending stage, and is flexible in terms of the type and quantity of content. How did you find this in terms of deciding how far to take your section of work, and how did it impact on scheduling and monitoring your time, your other priorities and obligations, self-discipline, etc?
2.4	Did you at any time experience overload and/or anxiety? Please elaborate.

Questions 2.1 and 2.2 dealt with prior learning and experience, and their relationship to ecotourism. The learners had rich and varied backgrounds. There was a social worker, a landscape planner, and geographers. Others were graduates in fields such as tourism management, botany, chemistry, anthropology, cultural history, and sociology. During 2000, they were honours- or masters-level students taking degrees in varied fields - agronomics (agricultural economics), tourism management, general ecotourism, environmental management, and the new masters degree in environment and society. Each discipline had to be applied and integrated into the new framework of ecotourism.

- ***Integration and bridging of learning***

  Class strength lay in its team expertise. Students reveled in the opportunity to apply their knowledge to a practical situation. Describing how their prior leaning related to the demands of the project, students compositely listed their knowledge and skills (Question 2.1) as:

  - *Sustainability of the resource base,*
  - *economic viability,*
  - *preparing documentation for decision-makers,*
  - *tourism accommodation models,*
  - *use of indigenous materials,*
  - *spatial planning and interrelations,*
  - *flora,*
  - *general problem-solving strategies,*
  - *heritage and culture of communities, and*
  - *community development projects., i.e. upliftment for the disavantaged.*

Where necessary, learning gaps (Question 2.2) were bridged in various ways:

Table 5C.9 **How I bridged learning gaps**	**Students** **(n = 12)**
Group interaction / Asked my colleagues	4
Asked questions of the lecturer	4
Readings on ecotourism / Library resources	3
Discussions with professionals	3
Personal research	2
My own creativity / Improvised	2
Policy documents on the Internet	1

The next aspect of cognition investigated (Question 2.3) relates to self-regulation of the learning process - planning, scheduling and monitoring the progression of the work. Several learners found the extent of the project more than they had anticipated. Their fairly detailed answers (provided descriptively, rather than tabulated) can basically be classified into six positive views, five negative attitudes, and three remarks about the type of content.

- ***Planning and self-monitoring***

  The six positive approaches indicated pre-planning and structured organisation. Learners had discussed their intentions with the facilitator and the group.

  I felt I knew what was expected to develop a quality product. /
  ... it depended on our self-discipline. /
  We had to set a deadline and work our schedules accordingly.

  The five who made negative comments were uncertain about the depth/detail required in the report, and some of them objected to the extra effort involved for real-world submission. This impacted on other academic commitments. One admitted a tendency to crisis management, which had delayed products and impacted on his group. There was also disagreement as to how far students should go in the content of the documents. Some felt that they should suggest ideas, but stop short of in-depth professional analysis and specific guidelines, while others wanted to generate a consultant-type document. One felt:

  The kind of solutions proposed should be flexible, so they can adapt and change to relevant situations.

The last question, Question 2.4, addresses the related field of affective aspects (2.3.4.1; 2.5.3.2), inquiring whether learners had, at times, experienced overload and/or anxiety. Ten responded in the affirmative.

Table 5C.10 **Elaborations on overload/anxiety**	**Students** **(n = 12)**	
Had other obligations / Impacted on my other studies	4	10
Took longer than expected / Were told to expand our project	3	
I was not familiar with what I was doing / Would have liked the final product to be up to a higher standard	2	
I had to do extra work to ensure a good product	2	

One learner expressed a particular concern:

> *I wish we had been able to visit the host communities (the dissatisfied ones) ...*
> *I am anxious about the eventual representativeness of our recommendations regarding them.*

Reserve management had explained local tribal grievances to the students, but considered a visit unwise, since it might exacerbate the problem of over-ambitious expectations. Another learner (in response to a different question) saw the community aspect as an opportunity for lateral thinking:

> Issues such as community relations gave one the challenge of applying his/her own mind to address the issue, as it is not theoretically conventional in nature.

5C.2.5.4 Concluding discussion

An important aspect of cognitive learning is the integration of new knowledge with prior learning. The relationship of new to prior knowledge varies from one case to another. For example it can be:

- *The same subject domain* where new knowledge is advanced material that builds on basic knowledge in the same content area, as in FRAMES.
- *A different subject domain* so that new subject matter must be mastered and related/applied to prior knowledge in another content area, as in RBO.
- *Similar domain, but applying theory to practice*.

The Mkambati 2000 learning event combines them all. The students represented prior learning in a variety of fields, each of which was a suitable foundation for the new discipline of Ecotourism. Each learner had to integrate his/her own background into this new expertise - in a research context - and apply it actively to the problem in hand. This was successfully achieved.

Planning and self-regulating of the report-writing progress was more complex, and was closely related to the affective-cognitive connection which varied over time. The survey reveals that attitudes which had been highly positive at the nature reserve, were less so during the prolonged write-up. Some learners did not appreciate the magnitude of effort required to produce a professional-type document, particularly since finalization coincided with preparation for exams. Ultimately however, what they learned had a high career value and each received written certification from the university and acknowledgement from the provincial authority of their contribution to an authentic exercise.

The Mkambati learning event encouraged critical thinking, particularly with respect to uncharted issues, such as community benefits and shared usage by local tribes-people of the reserve property. Further contentious matters, highly debated, were the nature of the accommodation - resort-type or eco-type - and the associated target group of tourists. The final proposals on these aspects were the result of reative compromises.

Integration of learning theories is again evident, as the investigation shows how cognitive learning in this project overlaps with customization, in that each participant's prior learning was the means of customization, as they focussed their contributions on their areas of specialization. Furthermore the cognitive-affective connection relates to the aspect of motivation addressed in 5C.2.1. The difference between the affective aspects of motivation and the affective aspects of the cognitive-affective connection is that the former relates to the role creative instruction plays in engaging and encouraging learners, while the latter comes into play once a learning event is underway, particularly at the stage where steep learning gain is expected of the learners.

5C.2.6 Constructivism

Features considered in this section of the investigation are real-world authenticity, personal knowledge interpretation, and the problem-based nature of the event. These issues are investigated as well as the foundations of grounded design (Hannafin *et al*, 1997) in the project. Constructivism is most appropriate for ill-structured domains, and the situation at the nature reserve is examined to match it against Jonassen's (1999) properties of ill-structured problems and Hannafin *et al's* (1994) characteristics of open-ended learning. Section 5C.2.6.2 is the most extensive of all the 'lecturer/facilitator viewpoint' subsections, as it depicts what made the Mkambati 2000 Project unique.

5C.2.6.1 Initial discussion

This section sets out the researcher's general impressions, as an observer-participant, of constructivist learning as implemented in the Mkambati 2000 event.

- ***Authentic real-world context***

While at the reserve, students spent time with stakeholders such as nature conservation officials, locals involved in successful ecotourism developments, and tourism operators. They heard about the issues from all perspectives, and became aware of roles played by local community needs and land rights, as well as the viewpoint of business that investment should realize returns. Learning was problem-driven (see 3.4.4.2 and 3.4.4.4; Jonassen, 1999) as the students:

- Were exposed to the complexities and multi-faceted nature of the problem, gaining new conceptual understanding,
- found out how and why situations deadlocked and proposals stalled, and
- learned advanced domain content in order to solve the problem.

They took ownership of the problem and reflectively explored the situation. They acquired new skills in decision-making, negotiation, accessing resources, and technical expertise. In generating proposals for presentation to the regional authorities, they did real-world work in a similar way to Steyn's (2001) learners, who were involved in a real-life development (Section 2.6.4).

- ***Values***

For this kind of more-than-just-academic learning to occur, students must be value-driven and self-motivated. As mentioned in 5C.2.3.1, some were passionate about a cause - doing post graduate studies as positive activists, with the desire to make a difference.

- ***Active participation***

Constructivist learning involves seeking and selecting relevant information, integrating it with existing knowledge, then organizing and applying it. Learning and literature have true relevance when applied hands-on. The researcher observed how, in the course of the fieldwork, the Ecotourism students formally interviewed and informally held discussions with stakeholders. They extracted relevant information, interpreted it in light of their own experience and research, and built new experiential knowledge over and above the formal domain content. Learner-initiative was encouraged, and this opportunity to state, explore, and debate their own ideas contributed to enthusiasm.

- ***Properties and learner-ownership of an ill-structured problem***

The purpose of the project was to present proposals for the way forward, based on the fundamental principles of ecotourism - yet addressing the unique complexities of the situation. System dynamics were fluid, due to the breakdown in negotiations with the successful tendering company, as explained in Text Box 5C. The future of the reserve, which had apparently been resolved, was once again uncertain, contentious, and topical - receiving attention in the popular press. Hence the genuine interest of the authorities in the students' proposals.

The situation - entailing conservation, botany, ecology, sociology, development of impoverished communities, business management and marketing, hospitality, adventure tourism, and ecotourism - complies with properties of ill-structured problems (section 3.4.4.2; Jonassen, 1999), namely:

- Unstated goals and constraints,
- multiple solution paths or no solutions,
- multiple criteria for evaluating solutions,
- uncertainty over which concepts, rules, and principles to use - or even - no general rules and principles for predicting the outcome, and
- the requirement that learners make and defend judgements.

When central issues are ill-structured, many aspects must still emerge and be defined by learners themselves (Jonassen, 1999). In this context, the four groups, under guidance from facilitators, took ownership of the problems, performed structured inquiry, and proposed solutions/guidelines in the focus areas (fauna & flora; activities for the ecotourist; culture & community; and accommodation, infrastructure, & facilities).

- ***Learner frustration***

Learner-frustration can be a feature of constructivist learning. The high point of Mkambati, namely, the real-world interest in the students' proposals, became a source of frustration when it forced a set of norms and a degree of excellence beyond the usual standard of students' products. The real-world exercise was excellent exposure and a valuable learning experience. It required time and energy commitment beyond the efforts usually spent on an academic exercise, but resulted in distinction marks for each group, when assessed by their university instructors.

- ***Grounded design***

For a learning system to be based on a grounded design (Sections 3.1.2 and 3.4.3.3; Hannafin *et al*, 1997), the foundations must be aligned to maximize coincidence and shared functions. The Mkambati 2000 learning event is examined with respect to five foundations, as was RBO in Section 5B.2.2.1:

1. *Psychological foundation*
   Learning in the project is related to *cognitive flexibility theory* as described in 5C.2.5.1 which focuses on the nature of learning in complex, ill-structured domains. Cognitive flexibility refers to the ability to spontaneously restructure one's knowledge in adaptive response to radically changing situational demands.

2. *Pedagogical approach*
   As in the case of RBO, the pedagogical foundation is *anchored instruction*, occurring in an authentic and holistic real-world setting, without any simplification of issues. Scaffolding, over and above prior learning, was provided in the form of multiple sources and reference books (marine ecology, fauna and flora, etc). The room used as a work area at the reserve was stocked with information on matters such as the SDI (spatial development initiative) envisaged for the region, material on loan from the authorities - such as submissions by consortiums who had tendered for the (now defunct) upgrade and development contract, and a proposal by a special-interest group to convert the reserve and its region into a national park. Large-scale topographical maps, Wild Coast hiking trails, relevant brochures, and marine-life charts were fastened to the walls, giving the appearance of a 'command centre'.

3. *Technological foundation*
   Laptop computers were brought along for note-taking and draft reports. During the subsequent report-writing period, technology was used as productivity tools - information was accessed from the Internet; databases and spreadsheets were used to manipulate and present information. A graphic presentation was also made on CD medium.

4. *Cultural considerations*
   As with RBO, the organisational culture and the norms and standards of the University of Pretoria were adhered to for assessment and grading of the four projects. Further cultural considerations were those relating to the host community, since all proposals had to exercise sensitivity to the locals and incorporate realistic benefits and policies regarding right-of-use. The culture of collaborative learning and team work played a major role in shaping the way the project unfolded - both in positive and negative respects.

5. *Pragmatic foundation*
   The project itself was highly constructivist, but when viewed in the context of the entire semester course which included decontextualized componential knowledge, the process demonstrates accommodation and balance, and uses all six elements of the HCMm. The prior class-based participative instruction served to lay a foundation for the ambitious field project. Just-in-time learning, only, would have been inadequate.

- ***Problem-based learning and open-ended learning***

Mkambati 2000 was an implementation of problem-based learning (see 2.4.5.4 and 3.4.4.4). The instructors did not generate or simulate the problem - it is an authentic real-world situation with complexities and uncertainties, and it entails multiple parameters. Characteristics of open-ended learning as set out in section 3.4.4.3 (Hannafin *et al*, 1994), are evident:

1. *Experiences on the field trip were embedded in context and experience* - such as exposure to natural environmental features and ecotourist activities (Text Box 5C), perception of negative problem-fraught aspects, and the positive contact with a local community involved in a self-employment ecotourism venture.
2. *Individual mediation of understanding* - learning was customizable to students' interests - allowing individuals to contribute according to their expertise and abilities, as described in Sections 5C.2.3.1 and 5C.2.5.3.
3. The process was *qualitatively different from the traditional instructional/learning venture*. To achieve the complex performance goals (Text Box 5C; Sections 5C.2.1 & 5C.2.2) and to engage in meaningful problem solving required:
   - Sound theoretical knowledge,
   - ability to apply that knowledge practically and circumspectly,
   - a wide variety of information sources (multiple perspectives), and
   - competent use of tools and resources.

- ***From personal interpretation to construction of a product***

Each group took ownership of its particular subproblem. Individual and group-interpretations were made, based on knowledge and personal experience. The interpretations and opinions were formulated as reports, proposals and guidelines, then collated and compiled into a single document of ecotourism planning guidelines in a consistent format, which was presented to the regional department of nature conservation.

5C.2.6.2 Viewpoint of the instructor-designer

Learning was highly active:

- Students had to find their own resources. They are given an extensive bibliography on ecotourism - but the project took them beyond its scope into related disciplines;
- After initial discussions during the field trip, they planned the reports on their own, until the stage when their first drafts were returned for changes advised by the lecturers. However, I was always available for queries and advice on resources, etc. One group in particular stayed close to me while preparing their document - the accommodation and facilities group.
- They actively explored the reserve to see for themselves what could be done there. The relatively long period (a full week) spent there was essential to the exercise.
- Lively interaction took place in the group discussions each evening, based on the places/issues they had seen/learnt that day. The ever-present challenge was how the principles of ecotourism could be applied right there in the reserve.
- The evening discussions were geared to the process of students having to work within a group within another group (as mentioned under the aspect of collabarative learning). However, as I moulded the final combined report later, I encountered a lot of overlap and inconsistencies which had to be sorted out.

Definitely problem-based:

- The students were given an authentic situation - the problem being that Mkambati has so much potential for ecotourism, yet nothing is really in place.
- They had to actively, and integratively, come up with solutions. The fact that we were giving the report to the provincial nature conservation department added an important dimension - this was a real task and with that came the responsibility that it had to be good - not just another student project. The students realized this, but were frustrated when they had to do a second draft - I don't think their commitment to a real-life cause went that far, because of their other pressures and responsibilities. I suppose that in the real world of professional consultants, the incentive of payment is a driving force!
- The evening working environment had the look and feel of a real-world operations room - piles of reference books, documents on loan from management, walls covered in charts, and large scale maps. We brought along different kinds of maps including various series from the Government Printer in Pretoria - some of them were maps that nature conservation authorities had not seen before and they were most interested.

Open-ended:

- The final products/ideas suggested by the groups - although there had been guidance along the way - were their own work. If two groups had done the same topic, each would have interpreted it differently and proposed different recommendations, i.e. there was no single solution, no right or wrong.
- Some ideas had to be re-visited and revised, due to constraints on them. For example - difficulties with local community made it complicated to suggest their involvement in certain ways. As I mentioned, we (the facilitators) gave much support in the process - mainly at the reserve, but depending on the students - some consulted us personally afterwards to discuss their suggestions, or made telephonic/e-mail contact.

Authentic, unique, and complex:

- I do not know of any other postgraduate project like it.
- Very complex due to the interdisciplinary nature of the problem and the intricacies of the Mkambati situation.

5C.2.6.3 Findings from survey of the learners

The following survey questions relate to constructivism and problem-based learning:

1.1	How did you find this experience of constructivist learning? Please describe your emotions honestly.
1.2	Describe both strengths and shortcomings, in your opinion, of this particular experience of problem-based learning - they may relate to any aspect or any stage of the project.
1.3	What sources of information did you use: before the trip / at the reserve / during write-up time afterwards?

The responses to Question 1.1 show appreciation of exposure to genuine constructivist learning in an ill-structured domain, in contrast to the usual academic experience of solving hypothetical problems. In a learner's words:

> *The challenge was to be able to work independently in a context with a high degree of uncertainty when theory and practice did not meet.*

Other elaborations are classified into categories and shown in Table 5C.11.

<table>
<tr><th colspan="2">Table 5C.11
Learner comments on aspects of constructivist learning</th><th colspan="2">Students
(n = 12)</th></tr>
<tr><td rowspan="3">Theory to practice /
Real context</td><td>Could apply ecotourism theory / combined real scenario with sufficient theoretical background</td><td>5</td><td rowspan="3">8</td></tr>
<tr><td>Applied and explored various planning approaches used in tourism industry</td><td>2</td></tr>
<tr><td>Creative problem-solving</td><td>1</td></tr>
<tr><td rowspan="2">Knowledge construction - Collaborative and individual</td><td>Accommodation of diverse ideas / collectively responsible / Interaction was the key</td><td>5</td><td rowspan="2">7</td></tr>
<tr><td>Active participation /
Problem-solving /
Could express own ideas creatively</td><td>2</td></tr>
<tr><td>Personal experience</td><td>Healthy experience / interesting /
Thoroughly enjoyable</td><td colspan="2">4</td></tr>
<tr><td>Fuzzy, ill-defined aspects</td><td>Community relations not addressed in conventional theories</td><td colspan="2">1</td></tr>
</table>

Question 1.2 addresses strengths and shortcomings of the event. In describing *strengths*, students spontaneously mentioned aspects that correspond with key features of contemporary cognitive and constructivist philosophies; these are listed in Table 5C.12 against the characteristic features:

Table 5C.12
Correspondence between constructivist features and learner-responses

Constructivist feature	Strengths mentioned by learners
Multiple perspectives	Gained a broad base of understanding due to: - Doing research one's self - the different views of teammates - students teaching each other.
Real-world problems Contextualization	An authentic problem situation: - own work / own opinion has value - guidelines may influence future decision-makers - deal with problem directly - gained perspective on complex situation - crucial exposure to real context - a challenge to think up new but viable solutions!
Learner-centered	Able to express own opinion / Could work independently
Creativity and innovation	Helped us develop intellectually and develop creative solutions / Informed decision-making / Motivated to be creative

The *negative* responses relate mainly to aspects already mentioned, and show that a constructivist paradigm calls for learner-adjustment. Value was added to the reservations by (voluntarily suggested) remedies, which are listed in Table 5C.13 alongside the identified shortcomings.

Table 5C.13
Shortcomings identified and suggested remedies

Weaknesses identified in learners' experience of problem-based learning	Suggested remedy
Writing up guidelines was complex. Needed more feedback from lecturers regarding the changes made to our documents.	A standard framework would have helped / We needed briefing on the kind of information that decision-makers need.
Frustrated by nature of the issues. Stress and high workload.	Needed more time (Researcher: other learners would not agree with solution above - they wanted less work!)
Huge project - took too much time.	Pre-planning should indicate the exact extent.
Group members did not all contribute equally. Not adequately equipped to handle it.	Evaluation should not be the same for all. / Peer review needed - to contribute to the mark.
Disagreement within group.	Should be channeled into constructive criticism
Group work is tedious and time-consuming. Some group members required direct instruction from others.	Sometimes I would have preferred a straight lecture.

5C.2.6.4 Concluding discussion

All three subsections indicate that this project is an illustration of classic constructivism. It supports problem-based, open-ended learning in the context of a poorly structured domain. The key features of constructivist learning such as active involvement of learners, freedom to contribute ideas and negotiate solutions, personal interpretation, and collaborative problem-solving are strongly evident.

The problem drove the learning and concretized the abstract:

> *Being onsite gave you a different perspective on theoretical jargon.*

Furthermore, a Tourism Management graduate, accustomed to conventional tourism models, stated:

> *I appreciated exposure to 'destination-specific variables' at a unique kind of destination*.

And a final comment:

> *It was great fun!*

Learners expressed reservations about certain shortcomings, one being uncertainty regarding the format, depth, and extent of the four final reports. Establishment of a standard framework to simplify write-up would not be a valid constructivist approach, since constructivism is not a prescriptive philosophy. Under the circumstances of meta-collaboration, however, such a framework might have been a pragmatic accommodation to simplify the unification of four documents into one.

The reservations relating to groupwork are valid; the problems mentioned are standard occurrences within collaborative learning and teamwork, and refinements to address them were proposed in 5C.2.2.4. The extent of work was undoubtedly more than envisaged by both facilitator and learners, and has been addressed in previous sections, particularly in 5C.2.5.4. All twelve students acknowledged the worth of the experience and in the long term, are likely to forget the peak-period pressure and appreciate the real-world career value.

This inquiry into constructivism in the Mkambati learning event shows that the field trip and project can also be viewed as an exercise in life-skills, as learners interacted with the facilitator, the 'clients', and one another, to grasp the problem and propose solutions.

5C.3 General

This section attempts to define the five facets of the wider learning environment of Mkambati 2000 and also briefly mentions the use of computer technology in FRAMES.

5C.3.1 Facets of the Mkambati 2000 learning environment

Table 5C.14 shows Perkins' (1991a; Section 3.5.4) five facets of a learning environment and their associated resources and implementations in the Mkambati learning experience.

Table 5C.14 Facets comprising the Mkambati 2000 fieldwork project
(Perkins, 1992)

Facets that comprise a learning environment	**Corresponding implementation in Mkambati 2000**
Information banks (some of which are part of the event's greater environment)	Reference books and class notes Conceptual models and maps Websites Stakeholders in the nature reserve
Symbol pads	Laptop computers Notebooks Maps-under-construction Cameras and binoculars
Construction kits	Software tools and packages
Phenomenaria	Internet and World Wide Web Real world natural environment Nature conservation officials, community, and tourists
Task managers	Facilitators Nature conservation officials Individual learners Co-learners

5C.3.2 Technology in Mkambati 2000

The Mkambati project, unlike the other two case studies was not founded on technology as an integral medium of communication. RBO is part of a degree in Computer-based Education, and FRAMES is a learning aid for a distance-education module, whereas Ecotourism is a contact-teaching course. However, it is required that students be familiar with software such as word processing, databases, and spreadsheets. Although none of the learners, who were registered for postgraduate degrees in a variety in faculties, were doing explicit computing-related courses, they evidenced sound competencies in the software packages they used as tools to manipulate, integrate and display information, and as aids in problem-solving, decision-making and communication.

5C.4 Conclusion to evaluation of the Mkambati Project

The final case study investigated the problem-based Mkambati 2000 learning event, incorporating fieldwork, report writing, and recommendations. The findings show that the learning event was well-designed, planned and executed, and that it achieved its aim (see Table 5.1) of bridging the gap between theoretical class-based learning and real-world hands-on practice.

Integration in Mkambati 2000

Different practical competencies, e.g. technological know-how, writing skills, and leadership ability, were applied in a holistic, collaborative, cross-discipline, and highly constructivist problem-solving exercise. The study and research incorporated elements of the:

- Human sciences,
- natural and environmental sciences,
- economic and management sciences, and
- man-made environment.

Five of the elements of the Hexa-C Metamodel, namely creativity, customization, collaborative learning, cognitive learning, and constructivism were strongly in evidence. Collaborative work was controversial. Some students put in more effort than others to ensure quality in the final products. Others may have been weaker students or else took a pragmatic view, being prepared only to devote a certain amount of time and effort. The team mark was a source of contention. Peer- and self-evaluation to contribute towards final individual grades could alleviate this problem. However, the experience was a foretaste of teamwork in the business and professional working environment. It is valuable exposure, and those who played major roles recognized the personal-growth factor.

Academically, learners were less threatened than in the other two evaluations. The challenge was posed more by the complexities of the application, than by inadequate knowledge and skills on their part (apart from the uncharted territory of the community aspects). Learners made in-depth investigations and applied lateral thinking in their efforts to solve an authentic problem.

Real-world worth

Value-driven learners were intrinsically and extrinsically motivated by the chance to do something real. It was a new experience to serve as consultants for a 'client organisation', the provincial authorities, who regarded them with credibility. However, when real-world academia becomes real-life in the workplace, final documents require a near-professional standard. Although the ultimate coordination and integration were the responsibility of the facilitator, it enforced high quality on the learners' deliverables and impacted on their other studies. It was demanding yet rewarding, and the efforts were worthwhile. After receiving the document of ecotourism guidelines, the regional director of nature conservation commented, 'It's wonderful to have a report we can use'. As with RBO, there are market-oriented benefits and long-term career value. Figure 5C.6, an extract from a student's interim project, sets out his impressions and the desire of these post graduate learners that their academic efforts might 'make a difference' in a pristine and fragile natural environment.

Figure 5C.6 The mission of Mkambati 2000 - in learners' terms
(Source: Pretorius, 2000)

Outdoor classroom on the Wild Coast

The relatively unknown Mkambati Nature Reserve on the Wild Coast, nestled between the Msikaba and Mtentu Rivers, was the venue this past week for a post-graduate practical excursion. Twelve students studying Ecotourism in the Department of Tourism Management at the University of Pretoria were putting theory into practice by developing ecotourism planning guidelines for this spectacular reserve.

The students, along with two lecturers, spent one week exploring the waterfalls, rivers, beaches, vulture colony, gorges, and fauna and flora of the area. Particular focus was placed on improving the accommodation, learning about the complexities of community involvement around the reserve, developing venture activities, and investigating means of interpreting the reserve to visitors.

Vital input was given by Mr Div de Villiers, Regional Manager Eastern Cape Nature Conservation and Mr Vuyani Mapiya, the manager of Mkambati. An extra dimension was added by Mike Proctor-Simms from the SABC who was interviewing on various aspects pertaining to the Wild Coast particular the issue of illegaL cottages erected on prime spots. In many cases, cottage owners are causing severe damage to the environment.

A highlight was a trip by canoe across the Mtentu River to visit a tented bush camp for tourists on the Amadiba Adventures horse trail from Port Edward. The students chatted to Eddie Russell, who has been instrumental in setting this up. It's an impressive Ecotourism operation - small-scale, with clear benefits to the surrounding communities and unobtrusively designed.

It is operations such as these that will keep the Wild Coast as special, unspoilt and unique as it is now. Places like Mkambati Nature Reserve play a vital role and need to be sensitively developed as well as economically viable. It would be a tragedy if the wrong type of development occurred along the coastline, turning it into yet another Kwa-Zulu Natal South Coast.

Asking the students what had stood out for them during their visit, they mentioned having a greater passion to conserve, as well as the importance of environmentally sensitive design and orderly spatial development. Others mentioned community involvement, the vitaL need for interpretation for visitors and the desire to keep Mkambati affordable. Overall, everyone felt that they had stumbled across a very special place, which, along with the entire Wild Coast needs to be sensitively and appropriately developed.

Back in Pretoria the students are getting stuck in as they finalise their ecotourism guidelines for the Mkambati Nature Reserve that will be presented to Eastern Cape Nature Conservation. They sincerely hope that their efforts can make a difference in this wonderful (yet endangered) part of South Africa.

As was the case in the investigations of FRAMES and RBO, interrelationship and overlaps were identified between the elements of the HCMm framework and are addressed further in Chapter Six.

Finally ...

The questionnaires ended with a general category in which the learners could comment on the value of the project (i) to them as an individual, and (ii) to the class. There were therefore 12 x 2 = 24 comments, and all twenty-four were positive:

> *Excellent learning experience / invaluable, real-world experience / practical exposure, enriching and meaningful / Learners could use initiative much more than in other courses.*

Four mentioned the value of teamwork, five the theory-practice relationship, and five the value of the experience as a market-oriented, professional development exercise. Finally, there is the worth of implicit training in life-skills and social development, embedded within formal learning, in line with the **values** incorporated within Reigeluth's (1999) 'new', learning-focused paradigm (Sections 2.6.5 and 3.6.2). A student from a formerly disadvantaged group spontaneously addressed this as he concluded his questionnaire:

> *Projects of this magnitude should be highly encouraged. For example, we get the opportunity to:*
>
> - *Know and appreciate one another*
> - *drive together, cook together, eat together*
> - *study together, hypothesize together*
> - *hike together, swim together, partake and participate together.*
>
> *The list is never-ending, depicting or epitomizing the spirit of togetherness and teamwork. I owe my gratitude to the organizers.*

5.2 Conclusion to the chapter

The research described in this chapter entails case studies, which used (primarily) qualitative methods to evaluate three learning events from the perspective of contemporary learning theory / instructional practice. The six elements comprising the framework of the Hexa-C Metamodel were used as tools to investigate whether and how each was implemented in the learning event, and what impact it had. It was found that the instructional design in each of the three events **solved the problem it set out to address** and, in general, **the theories and characteristics embodied in the HCMm were evident in the learning events**. Responding to the second research question, the investigation according to the theories and practices incorporated in the HCMm revealed notable information about the practice of effective learning. Furthermore the study demonstrated the versatility of the HCMm in eliciting valuable data in three very different learning events - different in purpose, content, and context.

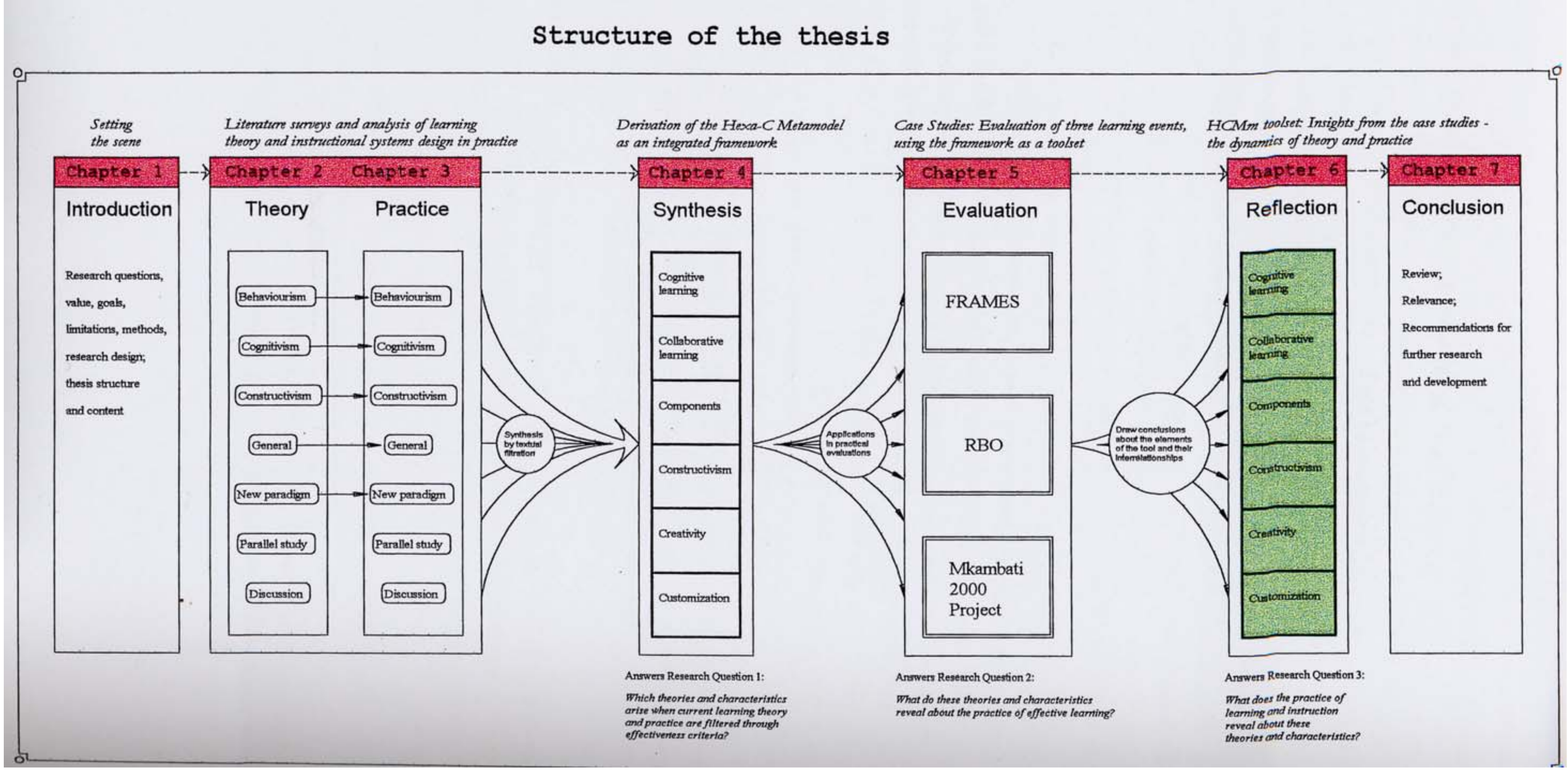
Learning-focused theory

Despite the differences between them, all three learning events also show characteristics which correspond with aspects of Reigeluth's learning-focused instructional theory (Sections 2.6 and 3.6). In Section 2.6.3 reference is made to learning environments that offer appropriate combinations of challenge and guidance, empowerment and support, self-direction and structure. Reigeluth proposes flexible guidelines for instructional situations in which learners:

- Take more initiative and responsibility for learning;
- Work in teams as well as individually on authentic, real-world tasks;
- Are able to choose from different sound methods to support learning;
- Use advanced technology as an integral part of the learning process;
- Are allowed to persevere until they reach appropriate standards;
- Participate in peer-teaching, using well-designed resources; and
- Operate in situations where the teacher acts as a guide and facilitator.

It is clear from the findings of Sections 5A, 5B, and 5C that all three case studies: FRAMES, RBO, and the Mkambati Project, comply with each of these seven conditions. It would appear **that learning events which manifest elements of the HCMm, do indeed conform to the new learning-focused paradigm.**

Chapter Five, therefore, used the framework as a tool to examine learning events. Chapter Six, conversely, uses the learning events to investigate the elements of the tool and describe ways in which each of the six can be implemented. This answers the third research question, by setting out what the practice of learning and instruction, in turn, reveals and informs about the theories and characteristics of the HCMm framework.


Structure of the thesis
Setting the scene
Literature surveys and analysis of learning theory and instructional systems design in practice
Derivation of the Hexa-C Metamodel as an integrated framework
Case Studies: Evaluation of three learning events, using the framework as a toolset
HCMm toolset: Insights from the case studies - the dynamics of theory and practice
Chapter 1
Introduction
Research questions, value, goals, limitations, methods, research design; thesis structure and content
Chapter 2
Theory
Chapter 3
Practice
Behaviourism
Cognitivism
Constructivism
General
New paradigm
Parallel study
Discussion
Synthesis by textual filtration
Chapter 4
Synthesis
Cognitive learning
Collaborative learning
Components
Constructivism
Creativity
Customization
Applications in practical evaluations
Chapter 5
Evaluation
FRAMES
RBO
Mkambati 2000 Project
Draw conclusions about the elements of the tool and their interrelationships
Chapter 6
Reflection
Cognitive learning
Collaborative learning
Components
Constructivism
Creativity
Customization
Chapter 7
Conclusion
Review;
Relevance;
Recommendations for further research and development
Answers Research Question 1:
Which theories and characteristics arise when current learning theory and practice are filtered through effectiveness criteria?
Answers Research Question 2:
What do these theories and characteristics reveal about the practice of effective learning?
Answers Research Question 3:
What does the practice of learning and instruction reveal about these theories and characteristics?

Chapter Six

Reflection

What the case studies reveal about the HCMm toolset

Tools alter the activity and are, in turn, altered by the activity
(Jonassen & Rohrer-Murphy, 1999:63).

6.1 Introduction

This chapter analyses the dynamics between various current learning theories, instructional systems design theory and -practice, and actual learning events. Using the framework of the Hexa-C Metamodel as a toolset, Chapter Five sets out findings revealed by the tools with regard to the three learning events, events that differ in purpose, content and context. Chapter Six, as indicated in the alternate chapter heading, conversely uses information from **evaluations of the learning events to examine the theories and characteristics which are the elements of the tool**. It answers the third research question in Chapter One, namely:

> *What does the practice of learning and instruction reveal about these theories and characteristics?*

This chapter sets out to extend and amplify the body of knowledge relating to the theories, characteristics, and practices that comprise the HCMm, using practice to inform theory.

Activity theory (Subsection 3.4.3.5; Jonassen & Rohrer-Murphy, 1999) postulates that tools alter the activity and in turn are altered by the activity as they adapt to its specifics - see quotation at header. This, indeed, was the experience in this study**:** When the Hexa-C Metamodel was used as an inquiry tool, information was obtained, not only about the **events evaluated** and the **dynamics of theory-practice**, but also about the **elements of the HCMm framework**, their integral inter-relationships, and ways of implementing them.

The HCMm toolset is investigated in-depth, using the practical applications studied in Chapter Five of the concepts and phenomena of Chapters Two, Three and Four. Notable features of the six HCMm elements are compiled, as well as ways and domains in which they may be implemented.

Section 6.2 contrasts the three learning events in respect of their context, use of technology, and the main thrust of learner- impressions.

The major part of the chapter, Section 6.3, addresses each of the six elements of the HCMm in turn. A critical analysis focuses on certain significant information revealed in the investigations. For each element, information revealed about its implementation and/or manifestation is tabulated - thus expanding and amplifying the body of knowledge. In further tables suggestions are made regarding ways in which the learning theories can (or should not) be applied - ways which differ from domain to domain. Implications and underlying rationale are provided where appropriate. Throughout the section a distinction is drawn between applying the elements of the HCMm in *well-structured* and *ill-structured* domains - a distinction elaborated in the first part of Section 6.3.

In Section 6.4 attention is paid to the way the elements of the model work together, indicating strong synergistic inter-relationships.

6.2 The three learning events

An *open system* capitalizes on fluxes, perturbations, and anomalies, and uses them as positive driving forces towards re-equilibrium (Jonassen, 1990). Models for designing instruction should be open systems, using positive, deviation-amplifying feedback to trigger internal changes, to regulate and renew the system. This is in contrast to negative feedback, which takes corrective measures away from erroneous deviations. The evaluations of instructional and learning systems in Chapter Five provide qualitative information, including both positive and negative feedback, illustrating the type of systems which Jonassen terms *becoming* rather than *being*. The findings should lead to **reflection by the instructor-designers** to capitalize on deviations, where appropriate, and adapt where required. This may result in systems functioning in a different manner from that initially envisaged.

Learning and instructional processes are dynamic systems and cannot be reduced to predictable, manageable operations (3.4.4.5; Jonassen 1990). Qualitative evaluation techniques help designers and instructors to understand complexity and the dynamics of theory and practice in the design, development, and delivery of instructional systems. The ethnographic research methods of this study reveal **as much about the six learning theories and characteristics** which comprise the framework, as they do **about the evaluated learning events** themselves.

This section commences by contrasting the three learning events, showing in Section 6.2.1 how they differ in context, approach, scope, and methods. Second, the use of technology in each case is examined in Section 6.2.2. Section 6.2.3 follows with a categorization of overriding learner-impressions of the learning events, based on responses to open-ended questions in the surveys and interviews. This integration of the three case studies serves as a background to Section 6.3, which examines ways of applying and implementing the six Cs of the framework in varying circumstances, contexts, and domains.

6.2.1 Contexts of the learning events

This study was enriched by investigating ways in which the six C-elements were applied and implemented in three **completely different learning events/environments**. Table 6.1 summarises the major learning contexts, conditions, and environments of the three events, supplementing their internal details set out in Table 5.1 in the introductory section of Chapter 5.

Table 6.1
Contexts, conditions and circumstances of the three learning events

FRAMES (Section 5A)	**RBO** (Section 5B)	**Mkambati 2000** (Section 5C)
Distance-learning		Contact-teaching
Discrete mathematics Department of Computer Science	Course in Internet-based Learning Department of Teaching and Training Studies	Ecotourism Department of Tourism Management
Computer-assisted learning system	Internet-based learning	Field work and project with class-based background
Procedural, well-structured domain	Ill-structured domains	
Not ideal for constructivism	Scope for constructivism	
Isolated learning, supplemented in some cases by co-operative pairs	Individual and collaborative learning	Collaborative groups
Customized by learner-options	Auto-customization	Customized by each learner's expertise and input
Full-time and part-time learners	Part-time learners	Mainly full-time learners
Undergraduates	Postgraduates	
No grading - a supplementary learning aid	Formal university courses - grading is compulsory	

6.2.2 Use of technology in the learning events

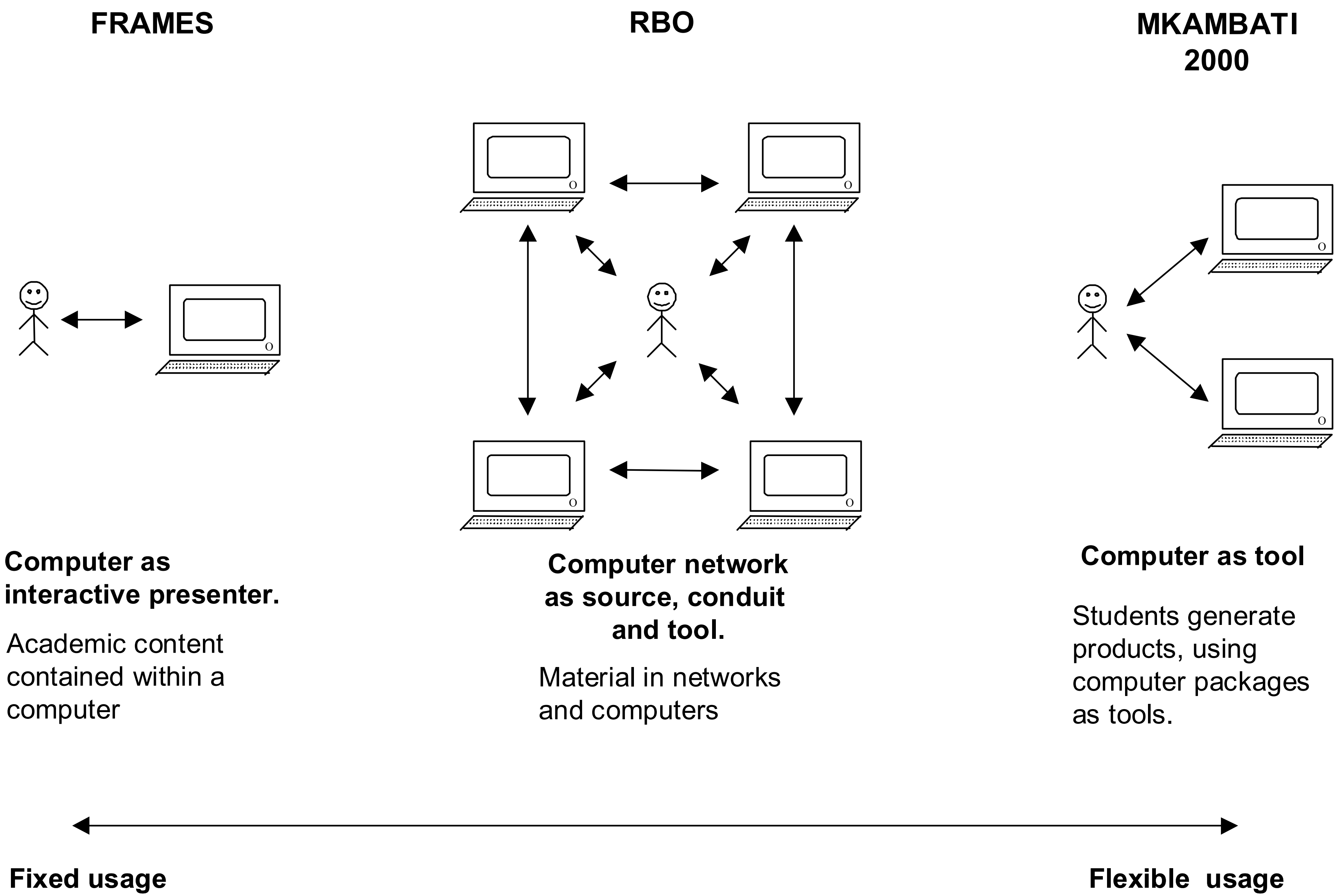
Table 6.2 categorises computer usage in the three learning events, showing the learner-content relationship according to Winn's (1992) *full* and *empty* instructional technologies (Section 3.4.1.1), and Figure 6.2 demonstrates the different ways in which the events make use of computers and software packages. None is inextricably coupled to a single computer system. Table 6.2 and Figure 6.2 are closely inter-related.

Table 6.2
Computer usage in the three learning events, categorised according to *full* and *empty* instructional technologies

Case study	Type of computer usage
FRAMES	**Computer as presenter:** A *full* technology containing information to be transferred interactively to students
RBO	**Computer network (Internet and WWW) as source, conduit, and tool:** The source of directives and basic information is a website For learner-generated products, the Internet functions as an *empty* shell which supports exploration, communication, and construction. RBO's Internet-based learning is transparent - learner-generated material is placed on the Web, available for fellow-learners to view, share, and access the underlying HTML code.
Mkambati 2000	**Computer as tool** Project-based learning, involving limited online exploration and communication; Major use of computers as separate, *empty,* offline tools.

Figure 6.2 graphically portrays similar information, depicting how the learners interact with computer technology in each event. In FRAMES the computer serves as an *interactive presenter* of a custom-built system; in RBO learners operate in an *immersive* (Harmon and Jones, 1999) Internet environment; while learners participating in the Mkambati project used commercially-available software *as tools* for manipulation and documentation. The three types of usage are situated on an axis indicating a spectrum of use from *fixed* to *flexible*.

Figure 6.1 Computer usage in the three learning events



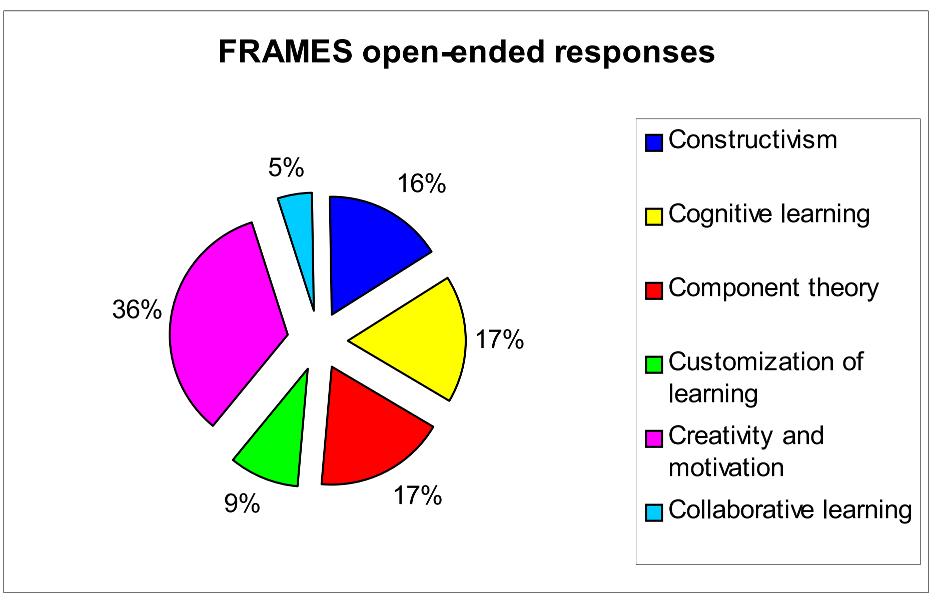
6.2.3 Learner-responses related to elements of the metamodel

The questionnaire surveys and interview questions for the three studies made considerable use of qualitative open-ended questions, which elicited spontaneous comments and insightful information. These spontaneous responses (most of which are also incorporated in Chapter Five) are categorised under the element of the HCMm framework to which they relate the most (although strong areas of overlap exist). Percentages are shown in the three pie-charts which comprise Figure 6.2.

Note: These charts categorize **open-ended descriptive responses** only, i.e. spontaneous, non-prompted impressions relating to elements of the HCMm. They do not represent answers to the kind of question that prompt learners with options that refer directly to elements of the framework. For example, the information in Table 5B.5 (see 5B.2.2.3), which indicates the large extent to which learners see constructivism in RBO, is not included in Figure 6.2.2, since this information was extracted from a question where learners selected from specified options. The extent of constructivism in RBO is therefore greater than indicated in the chart of Figure 6.2.2.

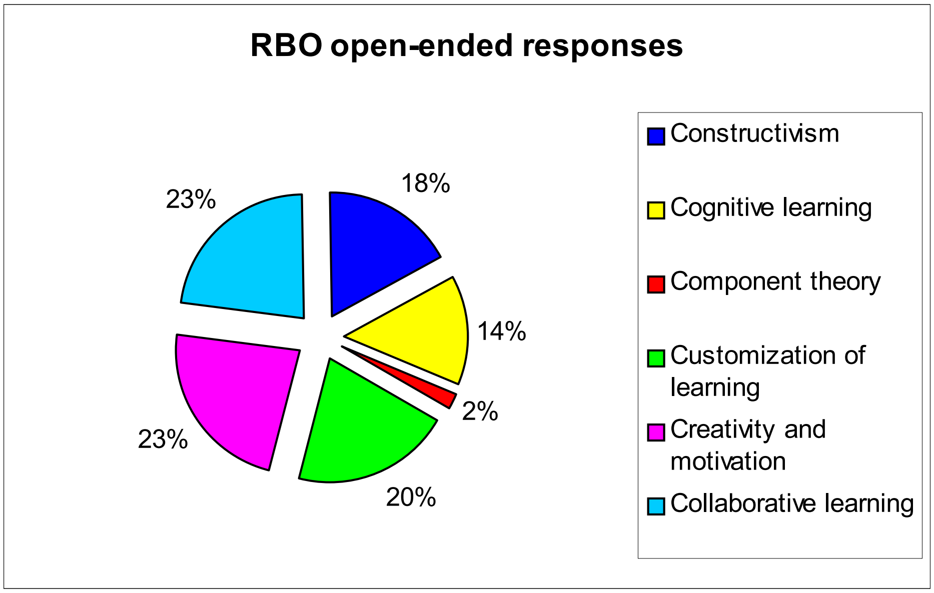
The open-ended responses in the FRAMES evaluation show the creativity of the environment and the way it motivated learners to be the learners' strongest impression (36%) - see Figure 6.2.1.

Figure 6.2.1 Categorization of FRAMES open-ended responses



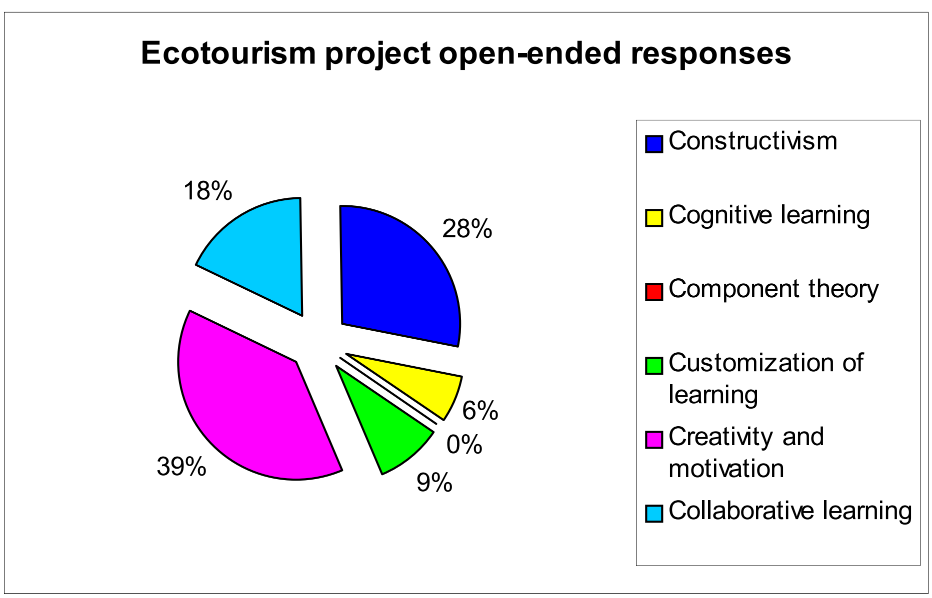
In the RBO evaluation (Figure 6.2.2), collaborative learning (23%) and creativity (23%) were jointly the aspects most frequently mentioned in open-ended responses, followed closely by constructivism (20%), which is actually an under-representation (see *Note* preceding the charts). The 2% recognition of components refers to the hyperlinks to tutorials and other basic resources.

Figure 6.2.2 Categorization of RBO open-ended responses



Among the Ecotourism students, 39% of the open responses related to the innovative nature of the project and the motivation and engagement experienced by learners. Constructivism follows, being the subject of 28% of the comments.

Figure 6.2.3 Categorization of MKAMBATI open-ended responses



6.3 The Hexa-C elements - investigating the investigation tools

Practice informs theory - as information elicited from the evaluations described in Chapter Five is used in a discussion of the Hexa-C Metamodel and its elements. Knowledge about the six elements of the toolset and ways in which they enhance learning and instruction is extended and amplified, incorporating variants noted in the study. The study was enriched by the differences between the learning events, as well as by the qualitative and descriptive research methods, which reveal aspects and insights that would not been recorded in a multiple-choice survey.

Under each of the next six headers is a series of tables with information from the evaluation study. The tables do not incorporate every possible aspect of the six elements, but rather focus on certain notable, less-known or specialized facets, including concepts from recent literature, occurrences of which were found in the evaluations. References are given in certain tables - both to previous discussion of a concept and/or its occurrence in the three learning events, but much of the information revealed by this study goes beyond descriptions in the literature. References to learner-responses in Chapter Five serve merely as an indication, and are not comprehensive, since substantiations of the findings are distributed throughout Sections 5A, 5B, and 5C.

Throughout this section, a distinction is drawn between applying the elements of the HCMm in *well-structured* and *ill-structured* domains (Hannafin, 1999; Jonassen, 1999) - concepts already introduced in this study (see 3.4.1.1:1, 3.4.2.5:1; 3.4.3.5, 3.4.4.2, and 3.4.4.3):

- Well-structured or 'closed' domains contain concepts and problems which are termed tightly-defined / well-formed / procedural, etc. Examples are the exact mathematical and physical sciences, procedural learning, and syntactical disciplines, all of which entail tractable problems.
- Ill-structured or 'open' domains contain problems which may be termed ill-defined / poorly structured. Complex, ill-structured knowledge is found in the social sciences, the humanities, and the design-and-development disciplines, where problems have multiple solutions and some aspects emerge only during the problem-solving stage.

Landa (1998) terms the well-structured domains 'algorithmic', and the poorly structured 'heuristic' - terminology which refers to the type of mental processes used for learning or solving problems within them. The algorithmic cases are solved by well-defined universal principles/processes, whereas heuristic situations can be addressed by a content approach, using reflective practice and heuristic, expert-type knowledge, which may entail using 'rules of thumb'.

6.3.1 Constructivism

Analysis of constructivism in the three varying learning events touches on the roles that active participation, real-world context, negotiation of project topic/content, peer support, positive use of errors, etc. play in personal knowledge construction. It was shown how these factors lead to higher motivation and a greater extent of work, despite the occurrence of 'constructivist frustration'. The discussion distinguishes between implementation of constructivism in well- and ill-structured domains. True constructivism was evident in two of the cases investigated in Chapter Five, where the problems were typically open-ended and unstructured. FRAMES, on the other hand, illustrates how constructivist variants can be effectively used in procedural objectivist environments, where there is a single solution to each problem or a tightly-defined defined problem-solving process.

The series of tables (Tables 6.3.1 to 6.3.3) shows factors from the investigations into constructivist manifestations in learning events, and addresses some of the *nuggets* of constructivism, 'nuggets' being particularly notable findings that emerged from the inquiries into constructivist manifestations in the three learning events. Some are manifestations of phenomena described in the literature; others are occurrences revealed by this research. Table 6.3.1 sets out information which amplifies and extends the body of knowledge on constructivism-in-practice.

Table 6.3.1 Information revealed about constructivism		
Concept	**Reference (within this study and/or original source)**	**Occurrence (or negation) revealed in evaluations**
Active participation and high interaction levels to engross learners ***Multiple presentation and varying perspectives*** to consolidate learning,	Section2.4.2.1; 5A.2.2.3 5B.2.2.3: Tab 5B.5, 5C.2.6.3: Tab 5C.11 5A.2.3.3, 5B.2.3.3, 5C.2.6.3 and Table 5C.12	**All three case studies**: Learning and problem-solving embedded in authentic contexts with support available to help learners comprehend theory actively and inductively, i.e. from practice-to-theory. This was shown to be a commonly-preferred learning style. **FRAMES**: Visual representations, opportunities to synthesize examples, use of examples and non-examples to illustrate real-world relationships. **RBO**: Multi-media resources on WWW and Internet; viewpoints of peer-learners. **Mkambati**: Presentations by peers, viewpoints of experts and stakeholders, paper-based and multi-media resources.
Negotiated ***personal learning goals*** and objectives	Section 3.4.2.1; 5B.1.4: Fig 5B.4; 5B.2.2.1, 5C.2.6.3	Could be determined in respect of some or all of the following: context, topic, content and extent. **RBO and Mkambati**: Overall goals and context imposed, but content open-ended.
Flexible assessment and ***strategic exploration of errors*** ***Assessment of constructivist collaboration; Complexities of constructivist grading***	Section 3.4.2.2; Lebow, 1993 5C.2.1.3 Section 5A.2.5.3 Section 2.4.2.2 Cunningham, 1992 5B.2.4.2, 5C.2.2.4	**RBO and Mkambati**: Learners capitalized on personal recovery from errors - identifying, exploring, & modifying invalid lines of approach. **FRAMES**: No exploration of errors - errors were system-diagnosed; remedial feedback was triggered. **Mkambati and RBO**: How to assess how much each learner contributed? Assessment that is not criterion-referenced.
Problem drives the learning	Section 3.4.4.2, 5B.2.2.1	**RBO:** Some learners tackled problems from their work environments.

Table 6.3.1 continued ... **Information revealed about constructivism**		
Perceptions (whether correct or erroneous) used as positive stimulants to create ***disequilibrium***, leading to ***reflection and restructuring*** on the part of learners	Section3.4.2.2 Lebow, 1993 5B.2.1.3, 5B.2.4.3 5C.2.1.3	**RBO and Mkambati**: Constructivism comes into its own where knowledge is complex and ill-structured and the domains are open-ended. This involves challenge, lack of boundaries, experiential learning, and self-responsibility for learning. Learners explored their ideas and provisional products; projected, reflected, and debated; and determined themselves whether or not they were on the right track.
Evaluation not criterion-referenced; But aimed at assessing learning gain, making use of multimodality, portfolio, self-evaluation, and peer- evaluation.	Sections 2.4.2.2 and 3.4.2.6; 5B.2.2.4; 5C.2.2.2 5A.2.3.3	**RBO and Mkambati**: More constructivist then FRAMES, yet ironically had the less constructivist assessment, since both are compulsory units of formal study, requiring grading to measure and rank learners, in line with university policy. **FRAMES**: An optional, supplementary learning aid, its single purpose is learning gain, and it has no scoring facility.
Incorporated subversion Participatory design, learner-experimentation, and ***adaptation of directives/material*** for own use	Section 2.4.5.3; Squires, 1999; Sections 3.4.2.5:2, 3.4.3.1 Willis 2000 5B.2.2.1, 5B.2.5.4 5A.2.2.3 5A.2.4.1, 5A.2.4.3	**RBO**: Constructivism-in-practice manifested incorporated subversion as learners, revelling in the lack of boundaries, generated innovative artefacts and produced unanticipated variations. Freedom to use learning event in the learner's own style resulted in: * Innovative artefacts and deliverables; * Extent of work beyond normal expectations; and * Totally subverted use in a negative way. **FRAMES**: Unanticipated incorporated subversion in the interactive practice environment as learners: * Improvised variations on standard features of the environment, using activity components in unexpected ways; * Co-operatively used activities designed for individual learners
Freedom from constraints	5B.2.4.3	True constructivism entails a lack of boundaries, which can impact negatively on other aspects of learning - for example, self-paced work is a constructivist feature that can obstruct collaborative work, particularly distance collaboration.

Table 6.3.1 continued ... **Information revealed about constructivism**		
Constructivism engenders ***cognitive conflict***, ***cognitive complexity,*** and initial ***learner-frustration*** when designers and instructors withhold explicit teaching and direct solutions, i.e. ***Constructivist frustration*** Real-world activities enforce high standards beyond the norm for academic efforts, thus demanding superior efforts	Perkins, 1991 Sections 2.4.2.1 and 2.4.3 5B.2.1.1, 5B.2.2.1, 5B.2.2.3 and Table 5B.6, 5B.2.6.3: Table 5B.13 'new tools' 5C.2.1.3 and Table 5C.5 5C.2.6.1 5C.2.6.3: Table 5C.13	This form of learning is not appropriate for all learners and can lead to attrition. Some learners prefer structured instruction, particularly those who struggle with the associated frustration. For those who persevere, learning is internalised and retained. They learn from solving problems, and frustration is an integral part of problem solving. However, support should be provided during frustration. **RBO:** Clear evidence of constructivist frustration **Mkambati 2000**: learners had to produce high-standard documents - beyond that of the usual student product. Some appreciated the experience; others viewed the additional time and effort as hardship.
Beyond academia: real-world becomes real-life … The requirement that constructivist tasks have real-world relevance often means simulating a real-world problem. In some cases, real-world projects become real-life products, usable in the workplace. ***Immediate dual benefits*** (related to above, but with a benefit that is external rather than personal to the creator)	Steyn, 2001 5B.2.2.1 and 5B.2.2.3 5B.2.5.3: Table 5B.12 and below 5C.2.1.1, 5C.2.1.3, 5C.2.3.3, 5C.2.6.1, 5C.2.6.3: Tables 5C11/12 5C.2.3.3 and 5C.2.6.3	Learning events that serve as academic exercises - generating credits for formal studies - but add value by generating artefacts that contribute to real-life solutions, usually to the learner-creators, applying them in their work environments, thus enhancing the quality/scope of that learner's professional performance. **RBO**: Learners were their own 'clients' generating products for use in their own careers. **Mkambati 2000**: Sound preparation for real-world consulting. The HCMm identified spinoffs where artefacts developed for academic purposes were functional in the market place, in policy-making and as resources in educational environments. **Mkambati 2000**: a provincial authority was the beneficiary.
Learners experience ***flow***; forget time; ***tackle more than intended or envisaged*** Or, conversely, resist additional effort	5A.2.6.3 5B.2.6.3: Table5B.13 5C.2.6.3; Table 5C.13	**All three**: Extent of work was more than initially envisaged. **FRAMES & RBO**: learners voluntarily tackled more than intended due to level of engagement/motivation. **Mkambati**: Circumstances required more than learners had envisaged.

Table 6.3.1 relates constructivism-in-practice (as evidenced in three case studies) to established constructivist philosophy and tenets, and has gone further in highlighting some **lesser-known constructivist attributes**. In particular, the table draws attention to:

- Strategic exploration by learners and error-recovery;
- The associated concept of disequilibrium as a result of erroneous beliefs;
- Reflection and reconfiguration of knowledge and beliefs; and
- Constructivist frustration - a form of cognitive conflict experienced by learners when explicit instruction is deliberately withheld.

The real-world features of constuctivism are shown to present learners with challenges and obstacles which, if they can be surmounted, will result in personalization and retention of learning, over and above the benefit of relevant, contextual knowledge.

Table 6.3.2 summarises certain findings of this study by listing ways of implementing constructivism. These findings **can serve towards guidelines or recommendations to be used by designers of instructional systems and learning events/environments** - both by professional instructional designers and by educators/practitioners who serve as instructor-designers.

The first part of Table 6.3.2 applies to constructivism in well-structured domains, where technical-rational approaches are used for well-defined, tractable problems with well-formed solutions (3.4.2.5; Schon, 1987). Nevertheless, aspects of constructivism can be effectively applied in such disciplines.

The next part of Table 6.3.2 relates to constructivism in ill-structured domains - the territory of uncertainty and reflection-in-action (3.4.2.5; Schon, 1987), where processes defy pre-definition and precise rules, being approached instead by flexible heuristic guidelines applicable to unique contexts and problems.

The section concludes with Table 6.3.3, which points out limitations on constructivism in well-structured procedural domains, where conditions preclude the full implementation of constructivist models and processes.

Table 6.3.2 Ways of implementing constructivism

Well-structured domains	**Constructivist approach**	**Implications**
Instructional features Closed problems, with a single correct solution for each Little or no scope for personal interpretation Procedural and algorithmic processes for problem-solving	High interactivity Active problem-solving with scaffolding Learner-control Multiple presentation modes (audio, visual, textual, interactive, etc.) Multiple perspectives From problem-solving to theory Non-examples as well as examples Learner-synthesis of examples	Keeps learners engrossed Learners tackle more than they intended Contributes to learner-centricity Supports different learning preferences Inductive learning Conceptual consolidation Conceptual concretization
Assessment and judgement Assessment in line with objectives All learners must grasp certain basic knowledge/skills Diagnostic assessment Learning measured as a proportion of what there is to be learned - testing, proficiency assessment, grading, ranking Communication/verbalization	Negotiated goals and personal learning objectives can contribute to self-evaluation / evaluation Absence of a scoring facility Conventional approach can be incorporated Journal-keeping / peer-teaching	Learners less threatened, nor is unwarranted optimism generated
Ill-structured domains	**Constructivist approach**	**Implications**
Instructional features Open-ended problems Multiple solutions Lack of boundaries Problem-driven learning Personal interpretation Non-procedural problem-solving and decision-making Social negotiation	Participative learning and high interaction levels Project- and problem-based learning Contextualized problems Multiple perspectives Personal learning goals Exploration of resources, discovery-learning, and experiential learning Collaborative learning Authentic / real-world problems Challenge Scaffolding	Inductive learning Deductive learning Supports learning preferences Value-driven research Personalization of problem and goals Preparation for the real world Solutions used in profession Learner frustration; cognitive conflict; some learners may not realize short-term benefits. Support in complexity
Assessment and judgement Learners do not all learn the same thing Subjective assessment of learning Assessment of gain and progress Assessment of collaborative efforts Positive use of errors Aim of learner-equilibrium	Multimodality / portfolio assessment Self-evaluation / peer- evaluation Evaluation against a learner's negotiated goals and personal learning objectives Grading of individual contributions; peer-assessment Strategic exploration Reconfiguration	Emphasis on learning gain and on the process rather than the product Perceived by learners as 'fair' Learning from misconceptions Reflection and recovery

Table 6.3.2 compares and contrasts ways in which constructivist learning can be implemented in the two kinds of domains. True personal construction of knowledge cannot occur in well-defined problems within well-structured domains, although variants of constructivist models and processes can be used. Table 6.3.3 addresses the limitations by mentioning some features of instruction in well-structured domains that preclude full implementation of constructivist models and processes. Yet moderate constructivist practices can be used as alternatives and supplements - see Table 6.3.2.

Table 6.3.3
Features of instruction in well-structured procedural domains

Approaches used that are out of line with constructivism (yet compatible with cognitivism - see Section 6.3.2)	**Constructivist approaches that are inappropriate or complex to implement**	**Implications**
Conditioning/guidance of learners to perform procedures according to a fixed pattern, in line with single/limited approaches, i.e. prompting learners in formation of specific schemata	Recognition of many possible solution paths and alternative correct approaches. Personal construction of knowledge/skill.	Human tutor can recognise correct alternatives, but not a CAI system. To automate this, artificial intelligence (AI) would be required to acknowledge all the alternatives. AI requires complex programming and knowledge-base techniques, which are not cost-effective.
Behaviourism in the form of remedial and diagnostic feedback to cut short erroneous paths.	Strategic exploration of errors Personal knowledge construction / interpretation.	Learners with low self confidence prefer system-diagnosis of errors to self-diagnosis.
Learners graded and ranked in line with institutional requirements. Scoring facility	Measurement of learning gain	Constructivist learning is simpler to attain than pure constructivist assessment.

Concluding remarks

Tools mediate the nature of human activity (3.4.3.5); and conversely an activity can be understood by comprehending the tool. Similarly, learning events shaped by constructivist design can be understood by grasping the underlying ethos; and conversely, the dynamics of the constructivism can be better understood in the context of use, i.e. the operation and evolution of constructivism and its role in instructional systems design can be better understood by investigating it in learning practice, as has been done in this thesis in three very different learning events.

This study has shown that constructivism can be implemented in rich and varied ways. It can be compatible with objectivism, and may be used to enrich direct instruction, as well as being independently used in problem-driven learning. An important contribution is the demonstration that pragmatic forms can co-exist alongside alternate paradigms in real-life settings.

6.3.2 Cognitive learning

Cognitivism, the bridge between objectivism and constructivism, is the key element of the HCMm framework. It relates in some way to almost every other element of the HCMm, since it was a delimitation of the study (Chapter One, Sections 1.2 and 1.6.2) that the learning theories surveyed should belong the cognitive family. As shown in Tables 6.4.1 and 6.4.2, cognitive learning can be supported in different ways, depending on the content being learned and the circumstances of the learning experience. The tables address some of the *nuggets* of cognitive learning which emerged from the case studies in Chapter Five, where the approaches and occurrences within the three learning events serve **as guidelines regarding how cognitive learning can, should and should not be implemented**. Table 6.4.1 shows amplified information about cognitive learning, as revealed in the case studies, while Table 6.4.2 contrasts the way in which concepts can be applied in well-structured and ill-structured domains. Once again the references in the tables to Sections 5A, 5B, and 5C, used to substantiate the findings, merely serve as indications and are not comprehensive, since such substantiations are distributed throughout the text of Chapter Five.

In implementing cognitive learning, designers and educators particularly stress aspects such as relating the new learning to prior knowledge and skills. This study describes a variety of relationships between prior learning and new, depending on the domain and the kind of knowledge/skills to be learned. The problem-solving approach also plays an important role, as does the cognitive-affection connection, which impacts in different ways at different stages - affecting learners' initial attitude to a learning event and their subsequent attitudes when diligence and perseverance are required.

Table 6.4.1 Information revealed about cognitive learning		
Concept	**Reference (within study / original source)**	**Occurrence (or negation) revealed in evaluations**
Prior learning and background knowledge Cognition is strongly related to the integration of new knowledge with prior learning. Traditional instructional structures build up knowledge incrementally, alternating teaching and question/practice segments. In case-based, problem-based & project-based learning, involving skills in ill-defined domains, explicit teaching is seldom incorporated. Prior learning is assumed to be in place, but links/references can be provided to external resources, either online or hard copies. Moreover, references to theory (explicit or subtle) can be built into the problem.	Section 2.3.2.1 Inhelder & Piaget, 1958 Section 3.4.4.4 5A.2.2.3 5B.1.4: Fig. 5B.1 5B.2.3.3 5C.2.4.2	The design of interactive learning and practice environments and that of open-ended learning experiences differ from the design of tutorial instruction. **All three case studies**: No mandatory teaching was incorpor-ated, even for structured knowledge and well-formed problems. Background information was available in various ways. **FRAMES**: Information was integrated: visual representations, generation of own examples; use of examples/non-examples to illustrate real-world relationships; definitions built into proof structures. **RBO**: Hyperlinks to multi-media resources on WWW and Internet; viewpoints of peer-learners **Mkambati 2000**: Presentations from peers, viewpoints of experts and stakeholders
The kind of ***prior learning that is relevant depends on the purpose of the learning event***, i.e. different kinds of prior knowledge integrate with the required new skills in different ways. New knowledge can relate to prior knowledge by being: ▪ In the *same domain* - advanced concepts, building on basic knowledge in same content area; ▪ *Different subject matter* - new content/skill must be grasped and related to prior learning in a former content area; ▪ *Similar subject matter* - moving from abstract theory to actual practice.	5B.2.1.3 & Table 5B.2 5B.2.2.1 5C.2.4.1, 5C.2.5.3, 5C.2.5.4 Text Box 5A	In answering similar questions re prior learning, responses in RBO and Mkambati 2000 followed different patterns. RBO respondents mentioned technical aspects and character aspects; Mkambati responses related to subject-matter expertise. Why the variation? Because there are different ways of integrating new knowledge with prior learning, and learners related to the question by recounting their paramount impressions: **RBO** stretched learners, requiring use of new skills - taking them out of comfort-zones into unfamiliar territory, technically and socially (distance-collaboration). **Mkambati 2000** applied prior theoretical knowledge as basis for practice. Territory, context, and scope were unfamiliar, but academically and socially, learners were comfortable/confident. **FRAMES**: addressed complex composite concepts - following on simpler basic aspects of the same content area.

Table 6.4.1 continued ... **Information revealed about cognitive learning**		
For some complexities, learners' ***backgrounds may be inadequate***	5C.2.3.3 5C.2.5.3: end	**Mkambati 2000**: The community issue - learners in uncharted territory need extra support in making in-depth investigations. In this case, they applied lateral thinking to generate heir own new solutions, but did not feel confident about their proposals.
Problem-solving structures and support strategies 1 In *well-structured domains*, step-wise presentation of problems avoids the cognitive overload that may be associated with worked examples in textbooks. Diagnostic feedback provides remediation.	Section 2.3.2.1; West, Farmer & Wolff, 1991 5A.2.1.3, 5A.2.2.3 5A.2.5.1: Tables 5A8 and 5A9	**FRAMES**: In all modes, including read-only, problem solutions were given step-by-step. Response-judging and diagnostic feedback are not constructivist ideals, but they enhanced cognition in FRAMES by attempting to explain errors. Several versions are stored to counter common errors, and learners are allowed more than one incorrect attempt before diagnostic feedback is given. This allowed a measure of exploration.
Problem-solving structures and support strategies 2 Learners typically tackle a problem, concentrating on what is *required* - aiming for conclusions prematurely, paying inadequate attention to using / deriving conclusions from *given information / available resources*	5A.2.2.3: schemata 5B.2.3.2	**FRAMES**: Cognitive learning is supported by templates that prompt learners to consider the theory at an early stage, thus facilitating the application of prior knowledge to the new situation. Visual links inter-relate associated concepts, prompting learners to integration. **RBO**: References provided by instructor and links to external tutorials were under-utilised.
Objectivist-constructist divide Cognitivism straddles the divide between constructivism and objectivism, and incorporates aspects of both.	Section 2.8: Figure 2.3 5B.2.1.1 5B.2.2.1: Figure 5B.5	**RBO**: Instructional methods and content are constructivist, but the course is presented in an organizational system with admission prerequisites and specified outcomes.

Table 6.4.1 continued ... **Information revealed about cognitive learning**		
Cognitive-affective connection 1 Motivation Maintenance of attention Twin statements by researcher: - Learners' values and emotions influence their ***initial ability to acquire knowledge,*** - Learners' motivation influence their ***ongoing attitude and attention.***	Section 2.3.4.1; Tennyson and Nielson, 1998; 5A.2.6.3 5B.2.1.3: after Tab 5B.4 5C.2.1.3 5C.2.1.3: Table 5C.5	The case studies demonstrated the researcher's twin statements. 1. When learners become rapidly engrossed, they learn better. Where the initial skills-gap is wide, particularly between academic concepts and real-world demands, anxiety is an issue. Adult learners feel threatened and find it stressful to bridge learning gaps. Attrition can be high. **FRAMES**: Learners were engrossed. **RBO**: Attrition prior to the evaluation and one learner afterwards; problem exacerbated by distance collaboration. **Mkambati**: Absorbed in the problem and the natural environment, Learners were stimulated to tackle the issues. 2. The second aspect was illustrated by the difference between the diligence levels of motivated and less motivated learners. Elements of the ARCS model should be applied where appropriate - in ill-structured domains, primarily the A and R of ARCS. **Mkambati**: Some lost enthusiasm during write-up.
Cognitive-affective connection 2 Stress and insecurity	Section 2.3.4.1, Tennyson and Nielson, 1998 5B.2.1.3: Table 5B.4 5C.2.5.3	**RBO**: Insufficient feedback - learners wanted assurance they were on the right track; overload; skills-gap. **Mkambati 2000**: Learner-stress was caused by uncertainty regarding what was required - breadth, depth, detail, etc.
Self-regulation and metacognition	Sections 2.3.2.1, 2.3.4.3 5B.2.1.6: self-regulation 5C.2.2.3: Table 5C.6 5C.2.1.3	**RBO** Some learners did not practice effective self-regulation; they missed deadlines. Some requested self-paced courses. Self-pacing is complex to implement within constraints of formal education. Poor self-regulation complicated collaborative work. **Mkambati 2000** Metacognitive adjustment in response to errors
Differentiation, integration, and construction as the three primary cognitive abilities to support effective learning processes:	Section 2.3.4.1, Tennyson and Nielson, 1998 5A.2.2.3, 5C.3.2	**FRAMES**: theory and practical skills were integrated. **Mkambati 2000**: theoretical concepts integrated with practice; Learners manipulated data and constructed new material.

Table 6.4.2 compares and contrasts ways in which cognitive learning should be implemented in the two kinds of domains.

Table 6.4.2 Ways of implementing cognitive learning

Well-structured domains	**Cognitive approach**	**Implications**
Instructional aspects Basic components are foundational knowledge for advanced content. Prior learning and new knowledge to be integrated Procedural / algorithmic knowledge Self regulation of learning	- Basic foundational knowledge should pre-exist, and be available, along with illustrations, on a just-in-time basis, rather than extensive direct teaching prior to any application - Visual aids and representations - Structures/methods to relate theory and practice - Step-by-step procedures - Cognitive-affective connection, use ARCS model - Structures to support higher-order thinking skills	Fast access, as required Scaffolds problem-solving Integrates theory-current problem Alternative perspectives Interactive supportive in problem-solving Avoids cognitive overload Supports metacognition
Entry, assessment and judgement Entry requirements Objective assessment All learners should grasp certain basic knowledge/skills	- Response-judging - Diagnostic feedback - Predefined objectives	Pinpoints errors and explains common errors to halt erroneous paths
Ill-structured domains	**Cognitive approach**	**Implications**
Instructional aspects Foundational knowledge serves as background Learner-anxiety in unfamiliar territory; learning gaps and attrition Self regulation of learning Heuristic knowledge	- Foundational knowledge on a need-to-know basis - Cognitive-affective connection, use A and R of ARCS model - Scaffolding - Self-paced (where feasible and appropriate), else planning & self-monitoring to meet deadlines - Independent use of HOTS - Build new skills on prior learning - Supportive feedback	Prior learning assumed to be in place; but supported if required Real-world training Learner-control Bridge the theory-to-practice gap
Entry, assessment and judgement Frequently entry requirements Subjective assessment Not all learners learn the same thing		

Concluding remarks

This analysis of cognitive learning sets out characteristics of the various types of domains and different ways of implementing cognitive learning within them.

In particular, cognitive-affective aspects should be addressed, so as to generate positive attitudes to learning. The theory-practice gap should be bridged, producing learners who are equipped for the real world. In line with its aim (Sections 1.3, 1.4.2), the goal of this study is to explore cognitively-based learning and instructional design theory, so as to support designers and educators and educators in facilitating effective learning, retention and transfer. Implementation of the cognitive approaches outlined in this section would contribute to this.

6.3.3 Creativity and motivation

The next element of the HCMm considered is the factor of creativity and motivation. The inquiry into creative instructional design and motivational aspects of learning uncovered a variety of issues in the three learning events investigated. The findings are shown in Tables 6.5.1 and 6.5.2. The former table suggests ways in which creativity, innovation and learner-motivation can be implemented, and addresses some of their 'nuggets' in supporting effective learning. Table 6.5.2 once again draws a contrast between well-defined, procedural domains and their less structured counterparts, suggesting how creativity can be encouraged and motivation supported in each.

References to Chapter Five serve merely as an indication, and are not comprehensive, since substantiations of the findings are distributed throughout Sections 5A, 5B, and 5C.

Two of the learning events show the value of a metaphor as an analogy to which learners can relate. Novelty also has worth in engaging its audience and holding attention, but any form of innovation must occur over and above underlying motivational factors that should instil in the target group a positive attitude and determination to succeed. Furthermore, novelty and innovation should not detract from content-learning.

A synergistic by-product is achieved when academic tasks contribute to personal self-development and career-worth, as took place in the two postgraduate learning events. A noteworthy observation in this study is the creativity engendered by creativity. Lack of boundaries stimulated learners and inspired them to generate innovative products and to reach high personal standards.

Table 6.5.1 Information revealed about creativity and motivation		
Concept	**Reference (within study and/or original source)**	**Occurrence (or negation) revealed in evaluations**
Metaphors and analogies	Section 3.3.2.3:2 West Farmer & Wolff 1991 (Branscomb, 1996) Text Box 5A 5A.2.1.3, 5A.2.5.3, 5A.2.6.1 Text Box 5B, 5B.2.6.1	**FRAMES**: The *virtual table top* and *andragogic activity box* of FRAMES are innovative metaphors. Learners' comments suggest a virtual coach - 'the person behind the computer' who 'has shown you how to do it' and 'It proves where you are wrong, and says "No guys, this is the way to do it" '. **RBO**: RBO learners identified themselves with the analogy and virtual surroundings of their *classroom-on-the-web*. Some played the roles of virtual pupils, referring to 'teacher' and 'bunking'.
Innovation and novelty Academic environments need not be sober and sombre.	Section 2.5.3.1 5B.2.6.3, 5B.1.4: Figure 5B.3 5B.4	Humour as a communicative medium is a contemporary societal approach. **RBO** is characterized by creative tasks and by humour. Its relaxed approach initially disguises its serious nature, and its depth and breadth. Designers should, however, be aware that not all learners identify with humour - the RBO 'frivolity' displeased one learner who claimed that it distracted from the real purpose of studies.
Creativity engenders creativity	Section 2.5.3.1 5B.2.2.3, 5C.2.1.3	**RBO and Mkambati:** Creative and innovative instructional approach fostered creative solutions and experimentation by learners.
Allow learners to make errors	Section 3.4.2.2: 5 5B.2.2.1 5C.2.1.3	Educators are often hesitant to allow learners licence to make mistakes. Allowing learners to make errors is thus a creative strategy. A significant feature of all three case studies was that learners found it a positive experience to deviate and self-correct.
Content as a motivator instead of artificial means (Some learners appear to believe that learning and enjoyment are inherently mutually exclusive!)	Section 3.7, Duchastel, 1998 5A.2.6.3 5B.2.2.3, 5C.2.1.3	**FRAMES:** Learners enjoyed what they were doing: 'Loved it' / 'I even forgot I was learning' **RBO and Mkambati:** Content & requirements were stimulating and challenging: 'I LOVE the educator-as-learner experience' (RBO), 'Captivated by scenery' (Mkambati). The achievement in completing demanding tasks was therapeutic and intrinsically rewarding.

Table 6.5.1 continued ... **Information revealed about creativity and motivation**		
Motivation Affective & motivational aspects affect learning in different ways:		
First, *creative features,* which can be considered as *external affective aspects,* and relate strongly to the outset of the learning event	Section 2.5.3.2	First, the external affective aspects: **FRAMES and RBO**: Novelty in content and presentation motivated and engaged learners. **Mbambati project**: The natural environment was a strong motivating force.
Second, the *cognitive-affective connection*, or the *internal affective aspect,* which occurs as learning proceeds. It is enhanced if the event optimises on personal skills/strengths, thus *empowering* the learner.	Section 2.3.4.1 5B.2.6.3: Table 5B.13 5C.2.1.3: Table 5C.3 5C.2.2.3, 5C.2.3.4 5A.2.6.3	Cognitive-affective connection - the internal affective aspect. This relates to issues which encourage/ hinder the acquisition of knowledge and skills, and which come into play during the course of a leaning event. **RBO and Mkambati**: Innovative aspects motivated learners to apply themselves. If learners reach a state of *flow,* an ideal has been achieved. **FRAMES:** 'I could do it all day' / 'I never think about time' Learners approach studies with mixed emotions - anxiety and stress are common. Adult learners tackling continuing education and life-long learning may feel threatened and inadequate, technology being a particular threat. Others approach learning with confidence, enthusiasm and assertiveness. Designers of instruction must address these conflicting needs. Options should be provided and varying degrees of support, so as not to bore the competent or arrogant individual, nor to intimidate learners who lack self confidence.
It is an added benefit if resources developed by adult learners are e used for *personal business and professional development* or to simplify work-related activities.	5B.2.5.3: Table 5B.12 and comments 5C.2.3.3	**RBO and Mkambati:** The synergy presented by personal professional development has both extrinsic and intrinsic benefits

Table 6.5.1 continued ... **Information revealed about creativity and motivation**		
Value systems Learning is work, and learners' value systems and attitudes are vital	Section 3.5.3; Wager, 1998 5C.2.1.3: Table 5C.2 5C.2.3.3 5B.2.2.3: Table 5B.6 and comments 5B.2.5.3: Table 5B.12 and comments	Where a learning event is intellectually and affectively challenging, a creative and innovative approach can motivate learners to produce beyond their own expectations. Working under novel and stimulating circumstances, learners in all three cases were surprised by their creativity and progress in demanding situations. In the open-ended situations, they appreciated freedom to use their expertise in paths of their own choice. **Mkambtai and RBO:** Value-driven learners are intrinsically and extrinsically motivated by the chance to 'do something real'. Where feasible, particularly with adult learners, persons with a vision and a mission should be able to use their studies to pursue ideals. Nevertheless, not all learning experiences are appropriate vehicles to do something real. Yet all should, by some means, promote hard work and effort.
Innovation engages learners, but must be used with care	Section 2.5.3.2	These characteristics hold learner's attention but must not obstruct the instructional message.
Some learners require more than intrinsic motivation. For competitive and results-driven individuals, motivated by achievement, the reward of placing high in a class is intrinsic as well as extrinsic motivation. An egalitarian system that avoids grades or that does not publish results may demotivate such achievement-oriented learners who require explicit recognition	Section 2.5.3.2 5B.2.2.3, 5B.2.5.3 5C.2.1.3: Table 5C.2	**RBO:** Learners' artefacts were acknowledged and used in the workplace. **Mkambati:** For a certain learner, the goals were high marks and recognition.

Table 6.5.2 compares creativity and motivation in well-defined, procedural domains and their less structured counterparts, showing certain similarities as well as differences in approach. The approaches listed can serve towards guidelines for designers and educators.

Table 6.5.2 Ways of implementing creativity	
Well-structured domains	**Implications**
Metaphor	Using the familiar as a bridge to the unfamiliar
ARCS model to: gain attention, ensure relevance, instil confidence, and lead to learner-satisfaction	Learning can be an enjoyable experience! Learners fully engaged in a task surprise themselves by the extent of work they accomplish.
Innovation	
All resources provided in single environment	Cognitive support
Incorporate elements of informality, fun and relaxation.	Reduces learner-stress and anxiety
Even in a closed domain, learners can be required to generate an open-ended artefact.	Scope for learner-creativity
Presentation of material on alternate media for perusal by learners	Asynchronous, own-place instruction/learning
Motivation	
Practical utilitarian value	Difficult work facilitated
Varied degrees of available support: offering challenge to the achiever and undergirding the less confident	Individual affective need are met Learners gain confidence as performance improves
Intrinsic motivation by supporting achievement	Extrinsic motivation is intrinsic motivation to the high-achiever
Affective-cognitive connection	Encourages persistence
Less structured domains	**Implications**
Metaphor Use context of adult learner's own profession	Unfamiliar presented in a context of familiarity Real-world solutions used by learners in own real-life environment
Innovation	
Scope for humour, fun and frivolity in traditionally sober academic environments/resources.	Stress reduction - learning can be enjoyable and even be perceived as fun.
Project-based tasks for learners	Learners may display astonishing creativity themselves.
Expose mature learners to professional consultant-type situations	Market-oriented training
Presentation of material on alternate media	Asynchronous, own-place instruction/learning
Permit erroneous ventures	Self-exploration and recovery
Motivation	
By real-world problem solving	Real-world worth for value-driven learners
Varied degrees of support	Individual affective need are met
Vision-driven activities	Intrinsic motivation

A further form of innovation occurs when the fundamental approach or medium is transformed, such as the current tendency towards distributed learning environments. Certain organizations are dedicated distance-educators, but in other cases a new genre of creativity is applied - namely 'distance-learning' models by choice - with WWW resources or material on intranets in laboratories being used to supplement class-teaching, but sometimes to replace it - as in RBO (Case Study 5B).

Concluding remarks

Creative instructional systems / learning events are those which motivate learners, and help them to enjoy learning. Creativity goes beyond the 'gold star' syndrome and achieves its ultimate **when content and/or context are the motivators**. Although creative individuals can demonstrate their creative faculties under any conditions, a creative environment nurtures further creativity. Finally, the affective-cognitive connection encourages positive attitudes and contributes to effective learning.

6.3.4 Collaborative learning

Table 6.6.1 sets out information about collaborative and co-operative learning efforts revealed by the three case studies. It incorporates positive aspects as well as complexities. Tables 6.6.2 and 6.6.3 respectively show some of the ways in which collaborative and co-operative learning can be implemented, and describe problems that can occur. There are references to previous discussion of a concept or its occurrence in a learning event, but these are merely indicators and not comprehensive, since substantiations of the findings are distributed throughout Sections 5A, 5B, and 5C.

The co-operative efforts of pairs at a computer in the FRAMES procedural domain enhanced learning and also made it a more enjoyable, social experience. The constructivist projects, RBO and Mkambati 2000, capitalized on teamwork to optimize strengths and support deficiencies.

The inquiry disclosed that collaborative work has its complexities. Interpersonal issues, delays, unequal contributions, grading are all some of the problems encountered. However, despite the obstacles, collaboration has intrinsic benefits - it entails life skills as well as subject-matter expertise, and is sound preparation for the real world and employment. Learners may complain that collaborative work is unfairly distributed, yet the hard truth is that collaboration is preparation for real-life and the working-day world, and these are not fair!

The inherent complexity of collaboration is exacerbated by further factors. The time period and the number of participants play a role. Another dimension that serves as an obstacle is distance. Distance collaboration, formerly almost infeasible, is currently offering new opportunities, yet brings its own unique set of problems.

Table 6.6.1 Information revealed about collaborative and co-operative work		
Concept	**Reference (within study and/or original)**	**Occurrence (or negation) revealed in evaluations**
Where collaborative learning is suitable: Collaborative problem solving is not usually suitable for algorithmic tasks where highly developed procedures pre-exist (Nelson, 1999). It serves well for heuristic tasks involving complex knowledge/skills. Where projects are open-ended, true collaborative learning, i.e. teamwork, can occur.	Sections 2.5.1 and 3.5.1 Nelson, 1999 5A.2.4.1: Table 5A.7 5A.2.4.3 5B.2.4.1:1 5C.2.2.3	This investigation suggests, to the contrary, that joint work <u>can</u> be done in certain structured domains. Co-operative problem solving, i.e. two at a computer - sharing expertise as they work through a fixed procedure - can be effective. **FRAMES**: Co-operative learning: Where learners lack self-confidence in defined procedures, discussion and joint decision-making with peers was efficient and effective. A learner mentioned role-reversal - after overcoming initial fear-block, he found himself the more competent performer. **RBO and Mkambati 2000**: The learning in these cases is a constructivist variant of collaborative learning. Contact-collaboration is preferable, yet distance-collaboration can be implemented, facilitated by the Internet. It is complex, yet it is collaboration which, formerly, would have been yet more unwieldy or even infeasible. The RBO *Opera* and the *Planning Guidelines* submitted to Mkambati authorities capitalized on synergistic integration of skills, multi-disciplinary expertise and practical competencies, e.g. technological know-how, writing skills, leadership ability, subject expertise, as well as social negotiation and interpersonal relationships.
Distribution of workload is an issue. Collaborative work is controversial. Some students take lead roles; others are frustrated by the requirements of fellow-learners. ***Rules and roles should be clearly defined***, as proposed in Activity Theory.	5B.2.4.3 and Table 5B.7 5C.2.2.3 and Table 5C.6 Section 3.4.3.5 Jonassen & Rohrer-Murphy, 1999	**RBO and Mkambati:** The more committed or motivated students take lead roles, doing more than a fair share to ensure quality. Others, possibly those of whom it was said 'not all students participated equally', may be weaker students or else pragmatic, being prepared only to devote a certain amount of time and effort. Dynamics of work distribution are complex, particularly in distance collaboration, and exacerbated when participants do not know one another. There were no rules regarding accountability to the group.

Table 6.6.1 continued ... **Information revealed about collaborative and co-operative work**		
Distance-collaboration is more complex than face-to-face collaborative learning.	5B.2.4.1:1 5B.2.4.3 5B.2.4.4	Without tight control, distance-collaboration can be inefficient. **RBO**: There were real and varied obstacles to groupwork, but the problems were overcome. Why distance-collaboration at all? Distance learning is traditionally an isolated experience. But technology-enabled distance-tuition has enhanced and expanded the experience - the Internet and WWW can provide rapid transmission of distance-learning material, available to a vast target. So distance learning has improved, why supplement it with distance-collaboration? First, it's an experience of real-world teamwork and personal interaction - virtual collaboration is better than no collaboration. Second, group work presents an opportunity to capitalize on strengths and minimize inadequacies. When team members have complementary knowledge and abilities the joint products are better than any individual could produce alone.
Where grading occurs, ***team marks are a source of contention.*** Learners claim: - Team grading is unfair - Participants do not all put in equal effort Designers of collaborative events should consider peer-evaluation and/or self-evaluation.	5C.2.4.3 5C.2.2.4	**Mkambati:** The evaluation indicated dissatisfaction with aspects of grading: Individual grading, based on each learner's personal efforts - with peer-evaluation and self-evaluation contributing towards the final mark, would help to solve the first problem in the left-hand column. Implicitly, the second would be less of an issue, since the more committed or achievement-oriented learners would be less driven to make diligent efforts on the group project to ensure their own mark. It could, therefore, reduce the quality of final products and be detrimental to the overall team effort! A compromise - recognising both joint and individual efforts in awarding a grade - appears to be best.
Co-operative work may expedite a process. ***Collaborative efforts are less efficient*** (though synergistic due to skills-mix).	5A.2.4.3 5B.2.4.3 5C.2.2.3	**FRAMES**: When two minds were applied to co-operative problem solving, efficiency increased. The activities mainly involved closed problems with fixed solutions, and joint perspectives enriched the process. **RBO and Mkambati:** Certain team members delayed proceedings

Table 6.6.1 continued ... **Information revealed about collaborative and co-operative work**		
Collaborative efforts function in different ways ***according to the time scale of the venture*** *The issue is* ***exacerbated in distance-collaboration***	5B.2.4.3 5B.2.4.3 5C.2.2.3	Short-term co-operation and collaboration are simpler than efforts over extensive periods. **FRAMES:** Short duration co-operative computer sessions worked well. **RBO and Mkambati:** Extensive and complex longer-term projects were demanding, as - Inter-personal variables and group dynamics came into play, - Attention-holding and diligence levels vary between individuals, which impacts on progress and flow of the project - some have initial enthusiasm but bore quickly or are easily distracted, - Time management for the group is a function of individual time management. 'Crisis managers' retard group progress. - The inherent complexity and ardour of long-term projects cause frustration.
Group size can retard / expedite progress	5C.2.2.3	**RBO**: Group size of eight was not optimal for distance-teamwork. Strategy, roles, and accountability should be pre-determined, and would be simpler with a smaller team.
Attitudes to collaborative learning depend on the individual	5B.2.4.3: Table 5B.7 5C.2.2.3: Table 5C.6 5C.2.2.3	**RBO and Mkambati**: There were both positive and negative impressions of interaction and collaborative learning. **Mkambati:** An achievement-oriented learner felt that joint accountability 'got in the way of ownership'.
Collaboration is excellent preparation for real-world applications in the workplace		Tables 6.3.1 and 6.5.1 addressed the value of 'real-world' experience in terms of the content of the learning. Similarly, the exposure to the rich synergism of collaborative work - as well as its complexities and drawbacks - is excellent preparation for the teamwork milieu of the working world.

Table 6.6.2 shows how co-operative and collaborative learning are used in the two kinds of domains - well-structured and ill-structured. In the latter a distinction is also drawn between contact- and distance-collaboration. More than the other elements of the HCMm, collaborative learning is characterised by complexities, and Table 6.6.3 briefly lists some of these problems.

Table 6.6.2 Ways of implementing collaborative learning
(mainly in the context of computer-based or web-based learning)

Type of domain	Implications
Well-structured, procedural domains, contact- or distance-learning Co-operative problem-solving, two-at-a-computer or work station (In the distance learning context, learners in same locality often form study groups)	Sharing of knowledge and skills increases competence and confidence. Discovery-learning occurs.
Open-ended domains, contact-learning Teamwork, collaborative problem-solving, joint projects Role allocation & role shifts Capitalization on strengths and support in weaknesses An efficient method of handling heuristic tasks based on complex knowledge systems	Sharpens interpersonal skills. Teaches relationships, power-sharing and power-struggles in a social context. Preparation for real-life team work. The combining of different knowledge in different ways, as well as discovery-learning.
Open-ended domains, distance-collaboration As above, using electronic communication Lacks factors of urgency and human dynamics that that go with face-to-face contact; ways and means must be sought to compensate for this.	Supports joint development of products. Processes are more time-consuming, particularly where participants do not know each other or one another's expertise.

Table 6.6.3 Problems incurred in collaborative learning

General issues	**Implications**
- Some carry more responsibility / do more work than others - Assessment of teamwork is contentious	Preparation for real-life! Learners request inclusion of peer-assessment and self-assessment
In distance-learning	**Implications**
Distance-collaboration issues: - Less control than in contact-collaboration - Team members can reduce output or drop level of communication, thus delaying progress - Not all team-mates carry equal share of work	Frustration and irritation (Bonus is that distance-collaboration can occur at all)

Team collaboration is inefficient for discovery-learning in procedural tasks or closed problems where a defined process that can be taught directly. Small group co-operative work can be useful here, as partners support one another in problem-solving. Collaborative learning is highly appropriate for open-ended heuristic tasks involving complex knowledge and skills that can be integrated in a variety of ways to solve a problem or complete a task.

6.3.5 Components

The practice of instruction/learning, as investigated in Chapter Five, also provides information about the theory of componential instruction. In all disciplines, learners must internalize certain basic knowledge and skill components. Some learning events are explicitly designed to impart this kind of knowledge, and in certain domains it is best to do this by explicit, even decontextualized, transmission using, for example, direct instruction via component-based tutorials (none of the learning events of Chapter Five are of this sort). Yet other instructional products (e.g. FRAMES) emphasize the practice of skills, but provide the necessary components as options, available when required. Other learning events, by contrast, assume components to be in place as a foundation on which further knowledge is constructed. In such cases, further contextualized learning by discovery and personal knowledge interpretation play a role, as occurred in RBO and Mkambati 2000.

The way in which components are taught and/or learned varies according to the domain. Tables 6.7.1 and 6.7.2 address the findings regarding the use of components in instruction and learning, and show some of the ways that instructional components can be learned and reviewed.

Table 6.7.1
Information revealed about components within instruction and learning

Concept	Reference	Occurrence (or negation) revealed in evaluations
Component display theory Based on the performance-content grid, to ensure that instruction covers the single and composite skills in a variety of ways. Learners make own decisions about the content and the strategy.	Sections 2.3.3.3, 3.3.3.1 and 3.6.1 Merrill, 1983, 1987 5A.2.5.3: Table 5A.9 5A.2.1.1: Tab 5A.2 Fig 5A.3 5A.2.1.3	**FRAMES**: Practice of skills and structured procedures is offered in a learner-controlled component-based fashion, as a supplementary learning aid. Theoretical information is provided as knowledge components; practical exercises are available as activity components.
Advanced, ***open-ended problem-solving*** is beyond the level of basic components. They should be present as a foundation.	5B.2.3.1, 5B.2.3.2, 5B.2.3.3 5C.2.4.1, 5C.2.4.2	**RBO**: Has links to external resources that include basic information - tutorials, websites, hard copy material, etc. **Mkambati**: Students came to the fieldwork with existing building-blocks of own discipline and ecotourism.
Deductive and inductive use of components	5A.2.2.3 5A.2.3.3	Some learners go from theory to practice; others in reverse. **FRAMES**: Theory built in to examples Practice-to-theory opportunities
The teaching of basic methods is a general occurrence in instruction. Whether or not, and how to incorporate them ***depends on the context***	Sections 2.6.2 and 3.6.1	Procedural and well-defined domains require explicit teaching of the basics. Ill-structured problems require foundation to be in place

Table 6.7.2 Ways of implementing the learning of basic components/skills (mainly in the context of computer-based and web-based learning)	
In well-structured, procedural domains	**Implications**
Domain components tutored or directly accessible Basic knowledge and skills, chunked into units Theory available within material/resource as an option. (Traditional CAI offers alternate teaching and question segments, but more contemporary approaches use a just-in-time basis.) There are also more complex composite components, such as principles/procedures of Merrill's CDT.	Fast internal access to basic information supports learners
Procedural / algorithmic knowledge, examples subdivided into steps, available within learning material / resource on just-in-time basis, initially	Avoids cognitive overload
Visual templates to support integration of theory and current problem or structued steps to scaffold the problem-solving procedure	Supports integration of components and principles into complex procedures
Interactive practice environments can be designed to offer far more than the conventional computer-based, program-controlled drill	Composite components are as important as unitary components
In open-ended domains / learning environments	**Implications**
Basic component/methods available externally Provide access to basic knowledge resources: - If learning environment is online, provide direct electronic links - If learning environment is offline, provide lists of resources	Does not detract from the purpose of the event as advanced open-ended problem-solving, but provides external scaffolding as and when required.
Contextualized learning - in some situations ***In other situations - decontextualized skills***	Elements not isolated in order to teach them, but learned within problem-solving Conversely, generalizable skills learned outside of contextualized problems

Concluding remarks

Components of learning, a cognitivist-behaviourist mix, are viewed by some as incompatible with constructivism, yet there is a complementarity between them. Components are used within direct instruction to transfer basic (or composite) units of content from the educator to the learners, while constructivism promotes self-construction and self-interpretation of information by learners themselves. Most domains incorporate different kinds of knowledge, some of which are best taught by components - unitary and/or composite components - and other forms that are better self-constructed.

6.3.6 Customization of learning, learner-centricity, and learner-control

Learning can be customized in many different ways, going way beyond the basic original concept of customizing by branched learning systems, also known as adaptive systems. Tables 6.8.1 and 6.8.2 address some of the nuggets of customized learning revealed in this study, particularly from the studies of three different learning events in Chapter Five.

Table 6.8.1 sets out information about customized learning as discovered in the three case study evaluations, explaining the difference between conventional learner-control and learner-centricity in the more contemporary sense. Learner-centred learning environments/events support learners in taking responsibility for their own learning. The table also describes how collaborative learning can customize an activity to individuals by providing opportunities for them to exercise their speciality/ies on a team situation. References to the literature and to Chapter Five serve to illustrate points, but are by no means a comprehensive cover of the rich findings of this study.

To set a background, branching, the original method of customizing learning, is briefly described in Table 6.8.2. Willis (1998) expresses reservations about traditional instructional design, which focuses attention *on strategies rather than on underlying principles*. This approach was a cornerstone of early customization, presenting options between alternative methods, and used particularly along with direct instruction. Branching between options was initially system-controlled as shown in Table 6.8.2, an approach incompatible with contemporary practice, since it can hinder design of the newer approaches to instruction and learning. In the rest of the table some of the newer cognitively-based forms of customization are shown, starting with learner-controlled branching and moving on to alternate, interrelated learning methods such as project-based and problem-based learning, case-based reasoning, and customization within collaboration. These truly learner-centric methods are used in domains that may well be compatible with direct instruction, yet where explicit teaching is complex to design. Auto-customization may entail learners making learning experience more powerful by taking them in different directions, i.e. having differing purposes as well as different ways of realizing them. Table 6.8.2 lists different ways of customizing learning, distinguishing once again between well- and ill-structured domains.

Table 6.8.1 Information revealed about customization of learning		
Concept	**Reference (within this study and/or original source)**	**Occurrence (or negation) revealed in evaluations**
Conventional learner-control in a procedural domain (Learner-control is not necessarily learner-centric)	Section 2.5.2 5A.2.5.1: Table 5A8 5A.2.5.3: Table 5A.9	Certain fixed material must be communicated to learners, making it less easy to implement learner-centricity. A way of doing so is to provide the required content, but without imposing fixed paths - a pick-and-mix situation. **FRAMES:** Learners customized the material by controlling the components / activities they did, selecting content, sequence, quantity, mode, and extent of help to meet their individual needs or stage of study.
Auto-customization, true learner-centricity For different learners, there can be diverse ends as well as diverse means of achieving them	Reigeluth, 1999; Section 3.6.3 5B2.5.2, 5B.2.5.4 5C.2.5.3: '*Integration …*'	There are two cases - tasks can relate to specified topics but have open-ended content; other tasks have open-ended specifications. In both, learners take responsibility for their own learning **RBO**: Auto-customization occurred as individuals steered the exam project in a direction of their choice. **Mkambati 2000**: Individuals used the tasks to do research in the directions of their specializations, but in ecotourist context.
Customization by content, as learners' backgrounds and interests are matched, and learning preferences realized.	Kearsley, 1998 5B2.5.3: Table 5B.9/10 5C.2.3.3: Table 5C.7, 5C.2.3.4	**RBO and Mkambati**: Students were able to personalize the learning experience and match their own interests.
Customization within team-based, co-operative & collaborative work, as learners finds roles in a group (Also preparation for the business and professional world)	Reigeluth, 1999 5B.2.4.1: 1 and 2 5C.2.2.1, 5C.2.2.4	**RBO and Mkambati**: Teamwork that optimized on each member's specialized expertise - teams can do what individuals may be unable to do, due to personal lack of particular skills/abilities. Diversity brought varied knowledge and talents to bear, and is a foretaste of the business and professional working environment.
Individually mediated understanding Learning experiences individualized	Hannafin *et al*, 1994 Section 3.4.4.3 5A.2.3.4 5B.2.5.1 and 5C.2.6.3	All three case studies: This thesis shows how understanding was individually mediated in three learning events, as self-directed learners took active responsibility for knowledge construction

Table 6.8.2 Ways of customizing learning	
Original way of implementing customized learning	
In well-structured, procedural domains, contact-or distance-learning	**Implications**
Branching System-controlled customization - Learner answers entry-questions - Based on responses, is placed by system on an appropriate path	Effective, if done as by a human tutor, as is the case in intelligent computer-aided instruction (beyond scope of this study)
Cognitively-based ways of implementing Customized learning	
In well-structured, procedural domains, contact- or distance-learning	**Implications**
Branching Learner-controlled customization - Learner chooses out of optional pre-set paths - Learner chooses own components/activities on a pick-and-mix basis (no pre-set paths or quantities) ***Multiple presentation / modes*** Same material, learner chooses from mode options and/or medium options ***Incorporated subversion*** Learner uses learning event in an original, unintended manner	Rigid, but appropriate for sequential domains True learner-control; learner-centricity as they select own sequence, quantity, even content. Consolidation of learning Supports effective personalised learning, since different learners learn best from different media and modes
In open-ended domains, contact- or distance-learning	**Implications**
Auto-customization / customization by content Use of a learning event in a way that is personally optimal; supporting diverse ends as well as diverse means: - Learners choose own approach within set content. - Learners determine own content and direction within a broad domain, or develop own product. - Learners choose own specialization/role within a collaborative team environment, i.e. use own complementary skills/expertise.	Usually learner-generated content, rather than basic taught-content
Individually mediated understanding - learner/s direct the learning, deciding what, how and when learning occurs, evaluating and explaining from experience in a problem-based/case-based context.	Instructor must guide and support, yet without controlling.
Incorporated subversion - learner uses learning event in an original, unintended manner.	Design should avoid rigidity, leaving space for creativity.
Customization by collaboration/team-learning	Capitalizing on unique individual abilities in context of teamwork.

Concluding remarks

Contemporary thinking on customized learning goes beyond individualization of instruction by means of branching. Alternative means of customization aim to engross learners and **match their interests** by challenging them in innovative attention-holding ways.

Customized learning is closely affiliated to learner-centricity, but the two are not synonymous. An instructional system can be customized by system-control, or even by learner-control, yet may not be truly learner-centric, i.e. not designed with the specific interests of the learners at heart. Conventional means of customization can be superficial (Reigeluth, 1996b), and the designers of instructional systems or learning events would do well to incorporate features that permit individual learners to match their particular needs and interests. It is more complex to implement this in basic instruction than it is in open, less-structured domains, where the newer concepts such as auto-customization, positive subversion, and customization by collaboration are appropriate.

With respect to educational technology, Kearsley (1998) points out the need, over and above teaching learners to use computers as tools for word-processing, spreadsheets, etc., to emphasize the cognitive abilities required to write, analyze, and formulate. Using computers as tools should entail problem solving, decision-making, manipulation, integration, and interaction with those tools. Learners who successfully attain these skills - with or without computers - and are able to **cognitively process, manipulate, and communicate information independently** are truly customizing their learning.

6.4 Inter-relationships and integration within the Hexa-C Metamodel

It has become clear in the course of this study that learning and instructional-design theories from the cognitive family are **dynamically interrelated with each other** as well as with the **characteristics** (in the HCMm) of contemporary instructional/learning practice. Each of the six sections in this chapter on a particular element of the Hexa-C Metamodel (Sections 6.3.1 to 6.3.6) presents a table on information regarding that particular element, as revealed in the case studies of Sections 5A, 5B, and 5C. It is notable that the references in these tables frequently point to material relating to an element other than the specific one under the spotlight, thus indicating their inter-dependency.

Two trianglular-format tables follow which set out relationships between each pair of elements in the HCMm framework. Table 6.9.1 shows positive factors, where theories/characteristics interact synergistically. Table 6.9.2 indicates a few situations where one element may rebound in a negative manner on another. Within the tables, each element is placed on both axes.

To investigate the **relationship between a particular pair**, the reader should locate each element on a different axis, then access their cell of convergence. To overview **all the relationships of a specific element**, access that element on the vertical axis and move right until the row ends, then move vertically upwards.

Cognitivism is the key element, interacting strongly with all the others to support or enhance them. *Constructivism* is a further major role player. As mentioned in Section 6.3.6, traditional ID focuses attention on strategies rather than on underlying principles. Constructivism, conversely, is more focused on principles than on strategies, and so concerned about changing thinking on instruction and learning that it can fall short in promoting practical ways of implementing the principles (Willis, 1998). Where true constructivism is achieved in a context that synergistically incorporates other elements of the HCMm, however, learning is achieved, the kind of learning that is transferable to other domains and that holds real-world outcomes. Regarding the relationship between customization and constructivism, Lebow (1993) suggests that the latter provides a much-needed theoretical basis for understanding learner-control strategies and guiding future inquiry. The crux of *customization and learner-centricity* is learners' freedom to choose their own focus and approach within a broadly defined context and content, a capability towards which all the other elements contribute. *Collaborative learning* is a characteristic that integrates harmoniously with the other elements, being a contemporary approach that effectively supplements conventional instruction as an integral part of open-learning and problem-based environments. According to Wager (1998), many cultural factors work against learning - such as cultural factors and learner norms. If time spent in collaborative work can also meet social and emotional needs, it should improve cognitive behaviour. *Creative, motivational instruction* is paramount in order to reach learners on an affective level, which is closely related to their ability to process information cognitively. The use of *components*, both unitary and composite components, is important at early stages of cognition particularly where some direct instruction is needed. Componential instruction and constructivism, though the antithesis of each other, are compatible in that each is optimal in a certain type of domain, and some domains optimize on both by employing them as supplementary forms of learning.

Table 6.9.1 Positive relationships between elements of the Hexa-C Metamodel framework

	Cognitivism	Collaboration	Components	Constructivism	Creativity and motivation	Customi-zation
Customization	*Prior-new learning:* Customize to relate to learner's background, expertise, &inadequacies. The way integration occurs depends on the types of knowledge to be inter-related.	Customize collaboration to *optimise on each learner's abilities* and minimize weaknesses.	When learners can *individually select* the knowledge and skill components, that they need, learning is more relevant.	Constructivism provides a theoretical basis for understanding learner-control/customization; Learners can choose own focus and approach within broadly defined context and content	Support auto-customization to encourage learner-creativity; Creatively match personal interests and needs to maintain learner-centricity	
Creativity and motivation	*Cognitive-affective:* Creative instruction helps learners to produce beyond expectations. Well-chosen metaphors simplify learning	The focus question of CLEs, OELEs, problem-based, and case-based learning should be creatively selected	Unitary components are usually de-contextualized, but composite ones can be presented in creative settings	*Not edutainment:* Learners from an entertainment-oriented society get bored easily. Use humour and novelty, but do not distract		
Constructivism	*Schemata construction:* Is facilitated by active participation *Cognitive anxiety*: Is part of constructivist frustration – adequate support must be provided.	*Social negotiation:* Helps construction of knowledge. Collaboration is an inherent feature of constructivism.	Components fall outside the ambit of constructivism, yet there is a complementarity and compatibility.			
Components	*Optional modes*: When components are available in optional modes, they support cognitive learning	*Peer-interaction:* Learner-learner communication and articulation of knowledge can consolidate learning				
Collaboration	Meet social needs in the learning process to reduce resistance, support learner-norms, enhance cognition.					
Cognitivism						

Table 6.9.2 Negative relationships between elements of the Hexa-C Metamodel framework						
	Cognitivism	Collaboration	Components	Constructivism	Creativity and motivation	Customi-Zation
Customization		Collaborative work can work against personal styles/needs				
Creativity and motivation		Tight regimentation of team projects can reduce uncertainty, but may impede learner-creativity.		Over-creativity and less familiar metaphors can overwhelm learners		
Constructivism		Being face-to-face & doing non-task activities, can strengthen bonds, therefore collaboration between remote partners is complex; Lack of boundaries in constructivism can impede collaborative efforts.	Components of knowledge and skills tend to be the antithesis of holistic knowledge construction, yet are supplementary to it.			
Components	Do not serve well in ill-structured domains					
Collaboration	Focused learners and achievers find that collaboration can slow down learning processes					
Cognitivism						

6.5 Conclusion

As stated in Chapter One, Section 1.4.2, the composite goal of this research, closely related to the three research questions in Section 1.2, is:

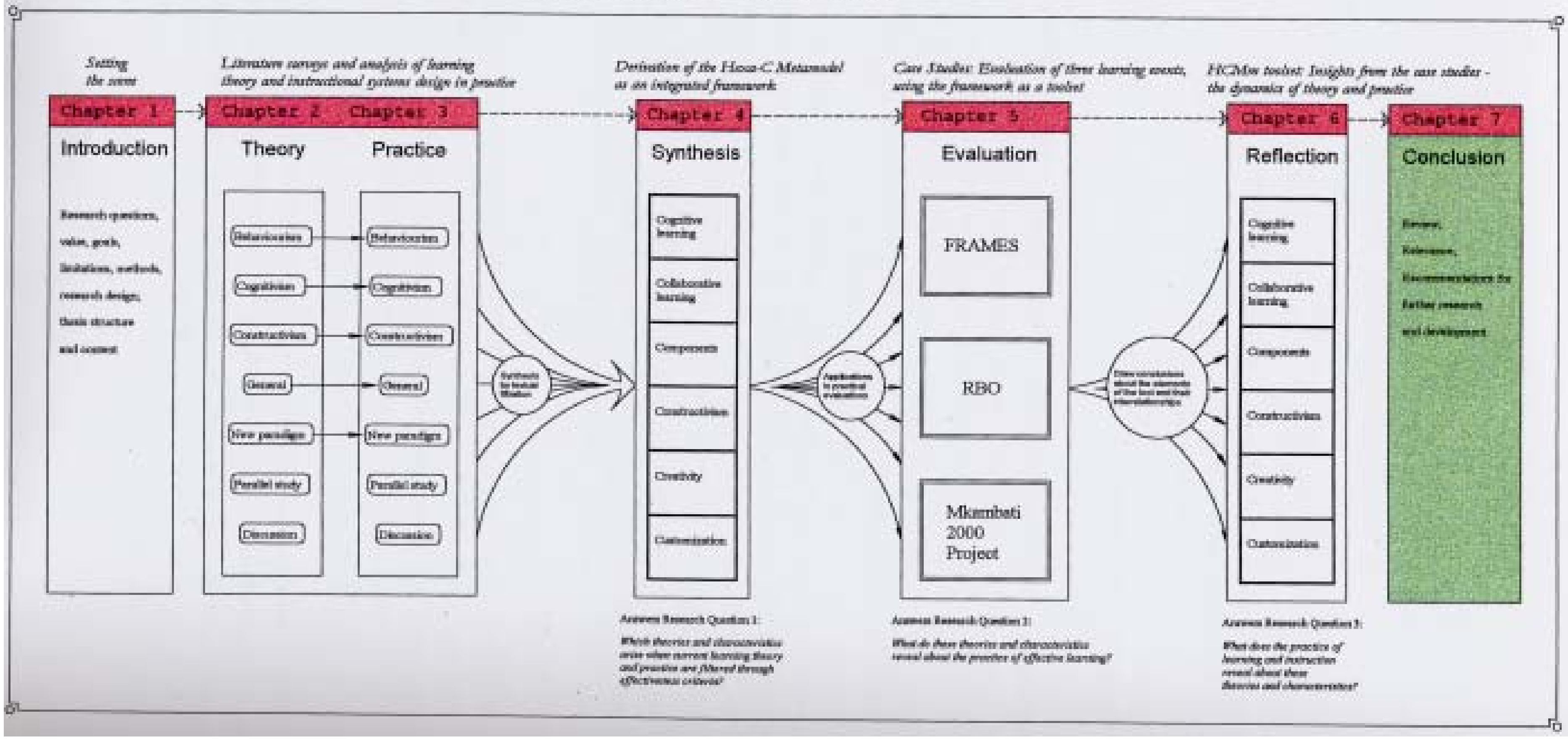
> To explore the current thinking in cognitively-based learning theory, instructional design theory, and effective practice, so as to develop a compact synthesis that can be used:
>
> 1. As a framework or tool to assist in the development of instructional systems, learning products, environments, and events;
> 2. For evaluating existing products, environments, and events from the viewpoint of learning theory; and
> 3. For determining further information about the dynamics of theories and characteristics embodied in the framework.

The **Hexa-C Metamodel**, which resulted from the first part of the goal, is not a rigid model with which learning products/events are expected to comply, nor is it a checklist of elements used to test conformance. It is clear, however, from the evaluations conducted in achieving the second subgoal, that **learning events and environments of which the characteristics correspond with most or all of the elements of the HCMm are effective in supporting learning**. In search of the third subgoal, each of the six C-elements was studied in-depth to determine what its use as a tool disclosed about it - in and of itself, as well as its role in the toolset. Information was tabulated about its use in practice and to suggest ways in which it could be applied in different kinds of domains. Where particular complexities were discovered, they were listed. The findings provided information about the HCMm as a composite, bonded framework, indicating a strong synergism between its elements. This study has contributed to the body of knowledge on the dynamics between theory and practice of current instructional systems design, by showing some of the most salient features of the literature, and indicating how they function in practice. Information has also been revealed regarding application of certain less-known aspects.

A further significant point is the convergence of the HCMm and learning-focused theory, an aspect introduced in Table 4.9 in Section 4.6. In Section 5.2, the conclusion to Chapter Five, the issue is pursued, where it is mentioned that each event: FRAMES, RBO, and Mkambati 2000, conforms to the seven guidelines for the new learning-focused paradigm as defined by Reigeluth (1996a; Reigeluth & Squire, 1998; and Sections 2.6 and 3.6 of this thesis).

Following the evaluations of Chapter Five, where the HCMm framework was used as a set of tools to investigate three learning events, Chapter Six, conversely, has inquired into the evaluations to determine what the case studies reveal about the elements of the tool and their inter-relationships.

Structure of the thesis



Chapter Seven

Conclusion

This thesis has investigated the dynamics of theory and practice in instructional systems design, with the purpose of synthesizing a compact and concise, integrated framework of current cognitive learning theories and philosophies, instructional design theories and approaches, and effective practices - a framework intended to facilitate the tasks of:

- Designing and developing instructional systems and events to support effective learning;
- Examining and evaluating existing instructional and learning systems/events/environments from the viewpoint of instructional and learning theory; and
- Determining more about the dynamics of theory and practice in the design of instructional systems and learning events.

This chapter closes the study, as it briefly:

- Wraps up what has been achieved (Section 7.1);
- Reviews the research questions which drove this study, and their answers (Section 7.2);
- Undertakes a final brief review of the Hexa-C Metamodel (Section 7.3);
- Mentions the relevance of the study regionally in South Africa (Section 7.4); and
- Suggests directions for future research (Section 7.5).

7.1 What has been achieved?

Using meta-analysis and a process of criterion-based filtration of textual information, a framework was generated, the Hexa-C Metamodel - a model of models. The HCMm is relevant to a variety of instructional systems, resources and artifacts, interactive learning environments, and open-ended learning experiences. Case studies were undertaken in which the HCMm was applied to three technology-related learning events: a computer-based practice environment, an Internet course, and a fieldwork project using computers as tools. Furthermore, the study contributed to the inquiry into learning and instructional theories by undertaking an in-depth study of the elements of the integrated framework itself, investigating the ways in which they function in different contexts and contents.

The reader is referred to Figures 1.2 and 1.3 in Chapter One, which depict the chain of reasoning in this study and show how the content and output of each chapter serve as the starting point of the next. This thesis has described the generation of a synthesis of theory and effective practice (the metamodel), investigated the dynamics of theory and practice in instructional systems design by using it as a tool to apply theory to practice and determined, conversely, how practice informs theory.

7.2 Research questions and answers

The research embodied in this thesis makes three main contributions as it answers the research questions of Chapter One, reviewed in Table 7.1.

Table 7.1 Review of the Research Questions

Research question	Addressed in
1. What theories and characteristics arise when current learning theory and practice are filtered through effectiveness criteria?	Chapter Four
2. What do these theories and characteristics reveal about the practice of effective learning?	Chapter Five
3. What, conversely, does the practice of learning and instruction reveal about these theories and characteristics?	Chapter Six

7.2.1 Response to Research Question One

Research Question 1 led to a concise integration of theory and practice in the HCMm framework.
Chapter Four describes how the Hexa-C Metamodel was derived and generated using a qualitative research process, which filtered textual information on learning and instructional theories/practice through nine effectiveness criteria – the purpose of the criteria being to select stances and characteristics that enhance both the learning process and the products of learning. The material used as *input* for this textual filtration process was the information from the extensive literature surveys of Chapters Two and Three. The synthesized framework, which was the *result* of the process, comprises three elements with theoretical orientations - **cognitivism**, **constructivism**, **components** and three which are characteristics of practice - **collaborative learning**, **creativity**, **customization**.

Although the HCMm is not proposed as the ultimate theoretical solution, nor as an all-embracing instructional design model or general evaluation checklist, it makes a contribution towards identifying salient features of the theory, design and practice of contemporary instructional systems.

7.2.2 Response to Research Question Two

Research Question 2 was answered by applying the HCMm as an evaluation toolset
The set of theories and characteristics integrated within the HCMm framework serve as an aid in instructional design and in the evaluation of existing learning systems, events, environments, and materials/resources. Within its three major sections for three case studies respectively, Chapter Five demonstrates how the framework was used as a versatile and valuable tool of inquiry in field research

for investigating the learning events from the viewpoint of learning theory. Data was triangulated by examining three very different designs for learning, selected for this study due to the researcher's close involvement with each, yet offering a further benefit in their eclecticism. The integrated and overlapping elements of the HCMm were used to investigate features intentionally designed into the learning events, as well as to reveal unanticipated factors - benefits, complexities and drawbacks.

The three evaluations, in which the researcher took a highly participatory role, showed clear occurrences of stances corresponding with most elements of the HCMm. Moreover, all three learning events resulted in effective learning processes, learner-achievement and -satisfaction, and educators who were satisfied with the progress of their learners. **It would appear that discerning application of the six C's enhances a learning experience or instructional system.**

As an evaluation approach, the HCMm provides a cognitive perspective to inquiry and identifies aspects *not usually revealed in evaluations*, since its framework relates more to the process and nature of learning than to the product/s used for learning. It provides insights into factors such as:

- Novelty of the learning experience, and the way it motivates/engages learners;
- Lasting learner-engagement, resulting in an affective-cognitive connection;
- The extent to which a learning event generates creativity within the learners themselves;
- Learning as constructed on a platform of prior learning, rather than as an isolated experience;
- The worth of teaching basic components as building blocks for subsequent integrated wholes;
- Active self-construction/interpretation of knowledge, rather than transfer of packaged knowledge;
- Learning as a continuous experience and contextual experience;
- Transfer and retention;
- Team learning and associated life skills;
- Relevance for and personalization to each individual learner;
- Learning that holds real-world added value;
- Application of technology that capitalizes on its unique capabilities, and
- Use of technology as a support, rather than as a structure itself.

Every instructional system or learning event has a particular, and sometimes even a unique, focus. Due to the consequent specialized nature of enquiries into different systems/events, the researcher has not proposed model evaluation instruments in this thesis. The HCMm represents a multi-faceted approach rather than a foundation for standardized proformas. Researchers or practitioners planning an evaluation can use elements of the framework to develop survey questions or checklists customized to the purpose of the particular artifact or learning event, i.e. they can apply the HCMm in a focused manner to record which theoretical issues are observed in practice.

7.2.3 Response to Research Question Three

Research Question 3 led to: learning more about the Hexa-C Metamodel framework itself

Chapter Six provides insights into the dynamics between theory and practice-in-action. Using the HCMm as a toolset to examine the practice of learning and instruction in three learning events also identified further information about the tool itself. The diverse nature of the case studies - differing in purpose, content and context - enriched and broadened the study, and contributes towards its credibility. Information emerged that:

- Contributes to inquiry into learning and instructional theories;
- Has practical implications, as it identifies commonalities/ and complexities that should be considered in the design and practice of instruction;
- Raises salient issues regarding teaching and learning with technology;
- Adds to the existing knowledge on the six elements that comprise the HCMm framework;
- Distinguishes between implementation of the HCMm's theories/characteristics in well-structured (closed) and ill-structured (open) domains; and
- Shows strong, and generally harmonious, inter-relationships between theories and characteristics that comprise the framework.

This thesis avoids proposing explicit design guidelines and recommendations, since it would be at odds with the constructivist nature of the study. Nevertheless the HCMm can play a valuable role as a design aid by prompting designers and developers to pay cognizance to the six C-elements of contemporary learning theory and practice. When one is informed by theory, the appropriate practical implications can be observed.

In the pursuit of facilitating effective learning, increased understanding has been gained of the *internal dynamics* – relationships and interactions between elements of the framework; and of the *external dynamics* – the relationship between the framework and actual instructional design/practice. Ways in which the elements of the HCHm framework should be implemented within an instructional system or learning event would depend on the content, context, conditions and circumstances of the situation. They would even vary between different presentations/applications of a program, artifact or event, depending upon the particular dynamics of theory and practice.

In line with the discussion in Section 3.8.2, the research methods used in this study permitted the researcher freedom and flexibility to investigate promising and unanticipated avenues in an ongoing process of theory development.

7.3 Final review of the Hexa-C Metamodel

The tables in Chapter Six detail a comprehensive study of the HCMm, investigating each element, as well as the framework as a whole, distinguishing between instructional design and practice in well- and ill-structured domains. Any attempt to summarise the chapter briefly would tend to trivialize this study; however, a few further points not raised in previous chapters are briefly mentioned here. They relate particularly to some of the strengths and weaknesses of the HCMm in its two roles as an evaluation tool and a design aid, respectively.

7.3.1 Strengths of the HCMm

7.3.1.1 As an evaluation aid

As an evaluation aid, the HCMm differs from the instruments generally used to evaluate instructional products. Traditionally, these focus on the efficiency and consequences of learning and incorporate quantitative metrics. The HCMm, by contrast – investigating from the perspective of learning theories and instructional practice - makes explicit the less tangible aspects. Any investigation using some or all of the elements of the HCMm is intrinsically a contextualized investigation.

7.3.1.2 As a design aid

The findings of the evaluations provided new and enriched information about the elements of the HCMm in use. Ways of implementing them in varying domains and circumstances are tabulated, and can be used by instructional designers and instructor-designers towards the formulation of guidelines appropriate for the product or program under construction, varying them according to the domain, the target group, and the stage of learning. The framework of the HCMm can support designers and practitioners in a multi-faceted angle of approach.

Instructional systems and learning programs **developed explicitly in the ethos of the HCMm** may result in learner-artifacts that have real-world worth. This holds particularly in the case of adult learners who benefit from spinoffs and added value in real-life, as products developed for academic purposes offer value in the market place, in policy decisions, and in their professions.

The role of technology in design is deliberately not over-emphasized in this study (see also 7.3.2.2). Technology serves as a powerful medium and/or tool and must indeed be effectively and creatively operationalized. However, the intention is that learners 'learn less *from* the computer and more *with* the computer' (Mehl & Sinclair, 1993:13).

7.3.2 Weaknesses of the HCMm

7.3.2.1 As an evaluation aid

The interrelated and overlapping nature of the six elements results in over-investigation of certain aspects, for example, the close connections between cognitivism and customization, between cognitivism and constructivism, and between constructivism and collaborative learning.

Furthermore, redundancy may occur, since not all of the six elements are applicable to all investigations or instructional design situations. For example, two of the three case studies - RBO and Mkambati 2000 - lie beyond component-based instruction. The HCMm serves differing functions within different learning events in different situations.

7.3.2.2 As a design aid

The HCMm has a valuable role to play as a design aid, as it focuses attention on the importance of learning theory in design and development and in instructional practice. As was mentioned in Section 7.1.3, it should support designers of instruction in paying cognizance to the six C-elements. However, the HCMm is not a design environment nor is it an automated instructional design system, but it can be used in a supplementary role to such.

Findings of the evaluations hold useful information for designers as they develop new events and artifacts. Yet the specifics of technology (which is the 'hub' of the hexagonal metamodel depicted in Figure 4.1 in Chapter Four) are possibly under-addressed within the evaluations. This may be more of an omission in the surveys and questionnaires than in the HCMm itself; however, the open-ended nature of the questions provided learners with the opportunity to address technological issues and aspects.

Technology, though positioned graphically as a hub, due to its relationship with all six elements, is not paramount within the HCMm (see 7.3.1.2). It is viewed as a medium and not the message - and should not carry the same status for instructional designers and instructor-designers as the actual content or problem-context of the learning situation.

7.4 Relevance to South Africa

In the current phase of national development in South Africa, transformation is a priority in the process of redressing the legacy of *apartheid*. Unfortunately, provincial and local authorities have limited funding for research to complement these processes, therefore expectations are increasingly turned on tertiary institutions to generate research that can be applied practically.

In this respect, the Hexa-C Metamodel can offer a contribution to the current educational situation in South Africa, due to its compatibility with outcomes-based education (OBE). OBE is proposed by the national Department of Education and Training as the way forward in the New South Africa (South Africa, 1998; South African Qualifications Authority, 2001).

OBE is part of a mission to achieve educational parity and to build a culture of meaningful learning within a body of learners with an historic dichotomy, spanning the spectrum from:

- Disadvantaged origins to privileged backgrounds; and
- Those who are recipients of poor education to those with excellent foundations.

OBE is founded on seven critical outcomes (South Africa, 1998; South African Qualifications Authority, 2001:5), these 'critical outcomes' being qualities that educators must aim to develop in students within the education and training process, regardless of the area or content of learning:

1. *Problem-solving skills*
   Identifying and solving problems in which responses show that responsible decisions have been made, using critical and creative thinking.
2. *Teamship*
   Working effectively with others as a member of a team, group, organization, or community.
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. *Communcation skills*
   Communicating effectively using visual, mathematical and/or language skills in the modes of oral and/or written persuasion.
6. *Technological and environmental literacy*
   Using science and technology effectively and critically, showing responsibility towards the environment and health of others.
7. *Developing macrovision*
   Demonstrating an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation.

The ethos and elements of the Hexa-C Metamodel are closely related to these seven intended educational outcomes. All except the seventh are aims explicitly incorporated within the HCMm framework as shown in Figure 7.1, and the seventh could well be achieved as a secondary consequence of the experiential and holistic thinking entailed in knowledge construction. Where an element, if appropriately used, could contribute directly towards achieving an outcome, the cell in the matrix is marked with a '**D**'. Where it can play an indirect role (e.g. peer-teaching of technological skills), it is indicated by '**I**'.

Figure 7.1
How the HCMm contributes towards the critical outcomes of OBE

Critical outcome	**Element of the HCMm framework**					
	Collaborative learning	Cognitive learning	Components	Construc-tivism	Creativity	Customi-zation
Problem-solving skills		D	D	D	D	D
Teamship	D			D		
Self-responsibility	D	D		D		D
Research skills		D			D	
Commun-cation skills	D		D		I	
Technological and environmental literacy	I	D	D	D	D	I
Macrovision				D		

This research, therefore, has practical implications for South Africa during its period of transformation of education. At a time when participatory, experiential, and interactive learning is required, the HCMm can be used in the development of resources and learning events and in the evaluation of existing ones. Learning events and resources that implement the elements of the framework will implicitly satisfy most of the critical outcomes.

7.5 Directions for further research

This section sets out opportunities for further research, building on this study as a foundation.

1. Guidelines and principles for the design of instructional systems

Application approaches, design principles, and practical guidelines should be drawn up for the development of learning events/environments/resources to facilitate effective and affective learning using the Hexa-C Metamodel. The design guidelines and principles would vary according to the application:

- Interactive learning environments;
- Web-based educational resources / online courses;
- Open-ended learning environments and constructivist learning environments;
- Direct instruction via textbooks, workbooks, lessons, and CAI tutorials, i.e. hard-copy printed resources, as well as computer-based products;
- Multi-media productions and videos; or
- Events and resources specifically intended to meet the seven critical outcomes (Section 7.4).

2. Evaluation principles for instructional systems

The theories and guidelines can also be used to generate evaluation criteria (from the perspective of cognitive learning theory) of interactive learning products, instructional websites, learning events/environments, and general educational resources.

3. Further evaluation

The learning events evaluated in Chapter Five were selected due to the researcher's close personal involvement in each, which is a requirement for action research and qualitative ethnographic analysis. It is proposed that the HCMm be used to evaluate further events:

(i) Learning and instructional systems/events/environments that are ineffective in supporting learning, or that give rise to problems;

(ii) Learning systems/products/events/environments with target group primary and secondary learners;

(iii) Adult corporate/industrial training in the workplace, as opposed to tertiary education for formal qualifications;

(iv) In-depth investigation of distance-collaboration and Internet-based co-operative work, and their problems; and possibly

(v) Learning events of a behaviourist nature (using a modified version of the HCMm).

4. ***Diagnostic evaluation*** (extention of 3(i) preceding):

The learning events evaluated in Chapter Five were selected not due to their effectiveness or success, but due to the researcher's close involvement and direct participation in each. The case studies show that each of the three was successful in promoting learning and engaging learners. However, the HCMm also has potential to be used as a diagnostic and remedial toolset. Research is recommended in its application to systems/events that demonstrate inadequacies or that are disliked by learners, in order to show what went wrong and why.

7.6 Conclusion

This study puts forward a dynamic integration of contemporary learning theories and the practice of instructional design. The proposed framework - encompassing the theoretical concepts of *constructivism*, *cognitive learning* and *knowledge/skills components*, as well as the practical characteristics of *creativity*, *customization* and *collaborative learning* - can make a contribution to instructional practice and support effective learning, as well as contribute to the inquiry into the nature of learning and instruction.

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Appendix A1

FRAMES EVALUATION:

Questionnaire used in a general evaluation, September 1997

This questionnaire contains general effectiveness questions, of which many also provided information for the parallel study, namely an evaluation from the viewpoint of learning theory.

The questionnaire survey was supplemented by random, unstructured telephone interviews.

Dept of Computer Science
Tel 012 429 6559 (Mrs de Villiers)
Tel 012 429 6817 (Secretary)
19 September 1997

Dear

Thank you for volunteering to join in evaluating the prototype of the interactive practice environment, FRAMES. It covers the more difficult kinds of relations covered in COS101-S. We hope that by now you have had hands-on experience of using FRAMES and can take a short while to complete the evaluation form. We would really appreciate your answers to the questions and any additional comments you might like to make. Please use the enclosed envelope to post it back to me in the Department of Computer Science.

All the best for your exam preparation. You are welcome to contact me or any one of the other lecturers mentioned in tutorial letter 103.

Yours sincerely

Mrs Ruth de Villiers

Before you look at or fill in the forms, please just write down BRIEFLY your strongest impressions about FRAMES in the space below and pop this into the envelope too. Thanks!

____

____

____

____

____

____

STUDENT-EVALUATION OF THE FRAMES INTERACTIVE PRACTICE ENVIRONMENT

NAME ____

DEGREE OR DIPLOMA FOR WHICH REGISTERED ____________________

STUDENT NUMBER ______________________________________

ADDRESS ____

____

____

PHONE NUMBER (H) _______________ (W) ________________

OTHER UNISA MODULES THIS YEAR ___________________________

UNISA MODULES PREVIOUSLY PASSED _________________________

____

Please put a cross in the appropriate block

1 The demo screens are easy to use.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

2 The demo screens helped me get started, so I knew what to do when I started the RAM exercises.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

3 When I do RAM exercises, I can easily access the one I want.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4 I like practicing examples on the computer.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

5 The FRAMES system is easy to operate.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

6 The blackboard-style definition of the current relation (P, Q, S, etc) at top left is helpful.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

7 The step-by-step build-up of answers:

Really helps	Makes no difference	Puts me off	Forces me to work in a way I might not choose

8 It is easy to access the HELP information such as definitions and graphic aids.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

9 The definitions (cartesian products, reflexivity, transitivity, etc) are a useful form of HELP.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

10 The attribute called 'EG' (for synthesis of ordered pairs in the relation) helps me to understand the relation.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11 The graphic aids help me get a feel of the relation.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

If yes, how? ____

____

12 I used the elaboration of maths symbols:

Not at all	Once or twice	The first few times I used FRAMES	Most of the time

13 FRAMES is complicated to use.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

14 It is easy to understand the meaning of the icons and symbols in the right-hand quick-control column.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

If not, which are not easy to understand?

____

15 I got stuck.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

If so, where? ____

16 I appreciate the learner-control that lets me do <u>what</u> I want, <u>as much</u> as I want and in the <u>way</u> (i.e. the mode) of my choice.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

At a typical practice session with FRAMES, I usually do ___________________________________

____

17 The feedback (i.e. the system's responses to my typed-in answers) was useful.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Please elaborate on your answer above - how and why the feedback was useful or otherwise.

____

____

____

18 I learned to use FRAMES:

Very quickly	Fairly quickly	Gradually	Slowly	Could not use it at all

If slowly or not at all, why? ____

____

19 There is too much information on the screen, i.e. the screens are too crammed.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20 The mode I <u>enjoy</u> using most is:

Mode 1	Mode 2	Mode 3

Why? ____

____

21 The mode that <u>helps me learn the most</u> is:

Mode 1	Mode 2	Mode 3

Why? ____

____

22 I find the processes lengthy and laborious.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

If so, which ones? ______________________________

____

23 The mode I like least is:

Mode 1	Mode 2	Mode 3

Why? ______________________________

____

24 I prefer doing exercises on paper.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

25 I find it difficult to use the RAM access method.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

26 It was useful having the structure of the proof set out in Mode 2 and Mode3.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

27 It is difficult using both the mouse and the keyboard to enter answers in Modes 2 and 3.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

28 After using the pre-set structures in FRAMES, I will know how to approach written examples in the exams.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

29 It is a waste of time doing interactive practice when I can read worked examples in the tutorial material.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

30 FRAMES helped me with the more complex proofs in the section of COS101-S on relations.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

31 I would use FRAMES in different ways at different stages in my studies.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

32 I know that FRAMES is intended to be a non-threatening practice environment, nevertheless I would like a scoring facility.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

33 I should like similar practice environments for other sections of my studies.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

34. Please make any further comments about FRAMES, including:

- the impression it made on you
- frustrations you experienced
- in what way it helped
- which examples of relations you found the easiest/ hardest/ most useful, etc.
- anything else you want us to know.

THANK YOU FOR YOUR INVOLVEMENT!

Appendix A2

'FIVE C' EVALUATION OF FRAMES:

Questions used a structured interview survey on aspects of learning theory, September 1998

(This was called the 'Five C' evaluation, since the sixth 'C', *collaborative learning*, was not envisaged for FRAMES. The evaluation indicated that students were, however, using FRAMES co-operatively.)

1 COGNITION

Has FRAMES changed the way you think when you solve a problem in the 'relations' section of COS101? If so, how?

Did the structures in Mode 2 help? If so, how?

Does it affect the way you will think in general problem-solving?
e.g. Will you classify a problem as a certain kind? / Be aware of a pattern to follow?

Think of the objects on a FRAMES screen and the way you interacted with an excercise - what helped you and how?
(Look for chunking, bridging from known to new, use of graphics, revision, use of rules and principles, etc)

2 CONSTRUCTIVISM

How does FRAMES help you learn new skills?

Do you enjoy being in active control (as opposed to passive , e.g in a book / video)

Would it help you do new problems? If so, how?

In what way do you use the graphic aids? (real-world, etc)

What about the step-by-step development?

How did you find working on FRAMES together with another student?

3 CUSTOMIZATION

How do you feel about being able to take the initiative in learning? / organize you own learning experience?

How do you find the feedback (FRAMES=responses to what you type in)?

How and when did you use the elaborations?
Would you use it in different ways at different times? (i.e. time-customization)

4 CREATIVITY

What do you find different about the way FRAMES lets you practice?

Do you get bored quickly when you use it?

Do you enjoy it?

Does it give you, on the screen, all you need to solve problems?
(i.e. virtual table-top)

Talk about ARCS (Attention? / Relevance ? Confidence ? Satisfaction?)

Could you maintain concentration?

Is it directly relevant to the type of problems you are asked in assignments and exams?

Does it help you develop confidence about this section of the work?

How do you feel when you=ve finished a FRAMES session?

5 COMPONENT-THEORY

How do you feel about the three different performance modes?

How did you find the different things you could do with the different attributes? (content)

Is it worthwhile to have the choice between doing very small and easy compontents
(e.g. a Mode 1 proof for one attribute) and at the other extreme, doing a whole Akind of relation@ anaysis in Mode 2 or Mode 3?

Note: There were no questions on co-operative learning, since co-operative use of FRAMES was nor envisaged. During the interviews, it emerged that three of the four interviewees were using FRAMES with a fellow-student.

Appendix B

RBO EVALUATION:

Questionnaire used in the comprehensive evaluation, May 2000

Questionnaire used in the evaluation of May 2000, in which two researchers co-operated and included their questions in a single survey.

Section F is devoted exclusively to questions on aspects of learning theory that were not included in the other sections. Section F does not address *collaborative learning*, which was incorporated elsewhere in the questionnaire, nor does it explicitly enquire about *components* of learning, since these were implicit, rather than explicit in RBO.

Questionnaire for the evaluation of the RBO course of 1999 and 2000

This questionnaire is to evaluate your perceptions and experiences of the RBO course on Internet-based learning / Computer-Assisted Communication and Management.

Section A: General information

1. Name: ___________________________ (optional)
2. Email address: ____
3. Age: (please mark the appropriate square with an "X")

18 - 24	
25 - 29	
30 - 39	
40 - 49	
50 - 59	
Over 60	

4. Gender: (please mark the appropriate square with an "X")

Male		Female	

5. Are you studying full-time or part-time?

Full-time		Part-time	

6. Job title and sector of employment:

____

7. Before doing the RBO course, had you used the Internet and the World Wide Web in teaching / training?

Yes		No	

7.1 If “Yes”, please elaborate.

____

____

____

8. With the RBO course behind you, what do you classify yourself as:
a newbie or a webbie?

Newbie		Webbie	

9. I am part of the RBO course of:

1999		2000	

10. I did the course as:

A credit for the MEd (CIE)?	
An “extra” module for the MEd (CIE)?	
An outsider – to be exposed to Internet-based learning?	
None of the above?	

Section B: Pedagogical issues

Please mark an "X" in the applicable box.

		Strongly Agree	Agree	Disagree	Strongly Disagree
The course, without the provision of face-to-face contact:					
1.	Adequately guided, facilitated and enhanced my learning.				
2.	Met my needs as an adult learner, i.e. relevant, self-directed, self-paced, flexible, hands-on, etc.				
3.	Provided adequate and effective communication amongst the learners and between learners and the instructor.				
4.	Facilitated individual tasks.				
5.	Facilitated collaborative tasks.				
6.	Supplied feedback to and assessment of our various tasks.				
7.	The course was a real learning experience.				
8.	I felt a sense of community building.				
9.	The environment was supportive.				
10.	I benefited from the electronic communication.				
11.	I would have preferred some face to face interaction, rather than e-mail only.				
12.	The course met my expectations.				
13.	I found the course exciting.				

14. What were the most important things you learned from this course?

15. How did you experience interaction with your class mates, e.g. useful/ supportive/complex/frustrating, etc?

16. Were there any issues relating e-mail communication and the chat sessions – other than technology-related – that were problematic, e.g. misunderstandings of meanings or intentions?

17. Besides the discussion that took place in the collaborative group tasks, why did / didn't you contribute to the discussion in general?

18. Did you use any other means of communication during the course with the facilitator or other learners, e.g. phone, face-to-face, fax, etc.

Yes		No	

18.1 If "Yes", why did you use this alternative method of communication?

Section C: Motivational and Affective issues

		Extremely effective	Very effective	Effective	Ineffective
19.	The course was effective in providing me with materials, models and metaphors that motivated me to learn?				

20. Did the course affect your self-esteem and confidence in any way?

Yes		No	

20.1 If "Yes", how?

---

21. One of the problems in collaborative learning is getting started. What factors influence group members to take initiative?

---

22. Were you at any point so engaged and absorbed by certain activities that you seem to "flow" along with it, experiencing a sense of happiness and satisfaction – glued to your computer?

Yes		No	

22. 1 If "Yes", which activities did this occur in, and what led you to this state?

---

23. If you were NOT registered for the M. Ed. (CIE) course, i.e. you took RBO as a guest, do you think there were any disadvantages you experienced from not having been in a previous study class with other participants. If so, what were they?

---

24. To what do you attribute your success/failure to perform during the course?

Section D: Learner Interface issues

Please mark an "X" in the applicable box.

		Strongly agree	Agree	Disagree	Strongly disagree
25.	The site layout and page layout was effective.				
26.	I could find my way around the site.				
27.	The design of the classroom motivated me to explore the site.				
28.	The page where the course's objectives and expected outcomes was helpful.				

		All of them	Most	Some	Did not follow links
29.	I read the instructions and followed the links from the RBO home page.				

30. What do you think of the design of the online classroom? Please elaborate.

____

____

____

Section E: Technological issues

31. Did you experience any problems with the following during the course?

		Yes	No
31.1	Hardware		
31.2	Software		
31.3	Internet connection		
31.4	E-mail communication with the Instructor / class members		
31.5	Chat room		

31.6 If "Yes", describe the problem(s) briefly, along with any others not mentioned above.

____

____

Section F: Learning Theories

32. Constructivism in RBO

Constructivist aspects in RBO				
To what extent did you experience the following aspects of constructivism in RBO880?	**Very great extent**	**Great extent**	**Moderately**	**Little**
32.1 Learning situated in the real world				
32.2 Discovery learning				
32.3 Anchored instruction				
32.4 Integrated testing				
32.5 Active construction of knowledge				
32.6 Transfer of skills				

32.7 As an educator yourself, how does it feel to be on the receiving end of constructivism – please describe your emotions honestly.

____

____

____

Cognitive learning in RBO

33.1 Describe how the knowledge and skills required in RBO related to your prior learning.

____

____

33.2 Where you lacked prior knowledge, how did you bridge the gap?

____

____

33.3 RBO students largely plan their own study / learning experiences. How does this work for you in terms of scheduling and monitoring your time, other priorities and obligations, self-discipline, etc?

____

33.4 Did you at any time experience overload and/or anxiety? If "Yes", please elaborate.

Yes		No	

____

34. Creativity in the presentation of the module

34.1 RBO is offered in an innovative, unconventional manner. Describe the innovative aspects you experienced, both in terms of the presentation of the module and in the content of the assignments, and how you feel about the approach.

34.2 What aspects and styles of this innovative approach did you incorporate in your own RBO project, or plan to use in your subsequent teaching ethos?

35. Customised learning in RBO

35.1 What are your personal learning preferences, and in what way did RBO match / mismatch these preferences?

35.2 Despite the "virtuality" of the classroom, most of us had some direct contact with the instructor, officially or unofficially. Do you find him approachable?

Yes		No	

35.2.1 Please elaborate.

36. The **conventional instruction paradigm** includes marks at intervals for students' interim test / assignments. How do feel about the lack of this in RBO?

37. How did you find the course useful in your personal or professional life?

Section G: General

38. What difficulties / barriers, if any, did you experience in participating in this course, that have not been mentioned in this questionnaire?

39. How did you find the course useful in your personal or professional life?

40. Is there anything else you'd like to say? Feel free!

Thank-you for your participation.

Appendix C

EVALUATION OF MKAMBATI PROJECT

Questionnaire used in the learning theory evaluation, October 2000

This questionnaire relates specifically to the elements of the Hexa-C Metamodel, with the exception of knowledge and skill *components*, since these were not explicitly part of this fieldwork project.

241 Fremontia St
Lynnwood Ridge
Pretoria 0001
October 2000

Dear Ecotourism Student

It was great to be at Mkambati with you - it's a week I will not forget. I was very impressed with your attitudes and approach to this real-world project. Thank you so much for the CD Rom of photos; it is so well done.

For my own academic work, I am doing research into learning theories. I have been given permission to use your Mkambati project, a form of 'problem-based learning', as a case study and I'd really appreciate if you would take some time to complete this questionnaire.

Thank you so much and all the best for your future studies and careers.

Ruth de Villiers

Tel (012) 361 6080

CASE STUDY: Problem-based learning in the Mkambati 2000 project of GGY 787 (Ecotourism)

Questions related to learning theory

1. Constructivist learning in the Mkambati Project of GGY 787 (Ecoourism)

Constructivism is a philosophy of learning that involves aspects such as:
- active participation by learners,
- construction of one's own knowledge, instead of direct instruction,
- authentic settings for learning, and
- problems which do not have a single fixed solution.

One of the implementations of constructivism is problem-based learning (PBL), where students, in groups, use resources in investigating open-ended, real-world problems, and the instructor acts as a facilitator. The Mkambati Project was an example of PBL - for a real, not a hypothetical, problem.

1.1 How did you find this experience of constructivist learning – please describe your emotions honestly.

____

____

____

____

____

1.2 Describe strengths and shortcomings, in your opinion, of this experience of problem-based learning. The strengths and weaknesses may relate to any aspect or any stage of the project.

Strengths: ______________________________________

____

____

____

Shortcomings: ___________________________________

____

____

____

1.2.1 What sources of information did you use?

Before the trip to Mkambati ____

____

At Mkambati ____

____

During write-up time afterwards ______________________________________

____

2 Cognitive learning in the Mkambati project

2.1 Describe how the knowledge and skills required of you in the Mkambati project related to your own prior learning (i.e. what you know from previous study).

____

____

____

____

2.2 In situations where you lacked prior knowledge, how did you bridge the gap?

____

____

2.3 Problem-based learning is open-ended. It has no fixed ending stage, and is flexible in terms of the type and quantity of content. How did you find this in terms of deciding how far to take your section of work, and how did it impact on scheduling and monitoring your time, your other priorities and obligations, self-discipline, etc?

____

____

____

____

2.4 Did you at any time experience overload and/or anxiety?

Yes		No	

If "Yes", please elaborate.

3. Creativity in the presentation of the Mkambati project

3.1 What motivated you in the Mkambati learning experience?

3.2 The requirements of learners in this project were innovative and non-conventional. Describe what you experienced as innovative and how you feel about the approach.

3.3 How did you feel about this project and the problem-solving approach?
For example, did it engross you, hold your attention, stimulate you, or did it frustrate you, bore you, cause you to lose interest, etc?
Please answer for all the occasions listed below:

Before the trip to Mkambati ______________________________

At Mkambati ______________________________

During write-up time afterwards ______________________________

4. Customized learning in the Mkambati project

4.1 What are your personal learning preferences, and in what way did this experience match/mismatch these preferences?

____

____

4.2 Were you able to personalise this problem-based learning experience to your own particular style, needs, passions, expertise, etc.?

Yes		No	

Please elaborate. ______________________________

____

____

4.3 Which of the following computer systems did you use?

Word processor	Database	Spread-sheet	E-mail	World Wide Web	Graphics Packages	Other (specify)

4.4 Did you experience the Mkambati project as learner-centred?

Yes		No	

Please explain. ______________________________

____

5. Collaborative learning in the Mkambati project

5.1 How did you experience the teamwork in this problem-based learning? Please elaborate.

____

____

____

5.2 What is your opinion about joint accountability and a team mark?

6. General

6.1 How did you experience the balance between instruction (lecturing related to the Mkambati) and independent work in this project?

6.2 Please give your comments about the value of the Mkambati project to you as an individual.

6.3 Please give your comments about the value of the Mkambati project to the class.

Finally (optional)

Your name and contact number, just in case I'd like to call you and ask a few more questions.

Any thing more you'd like to say.