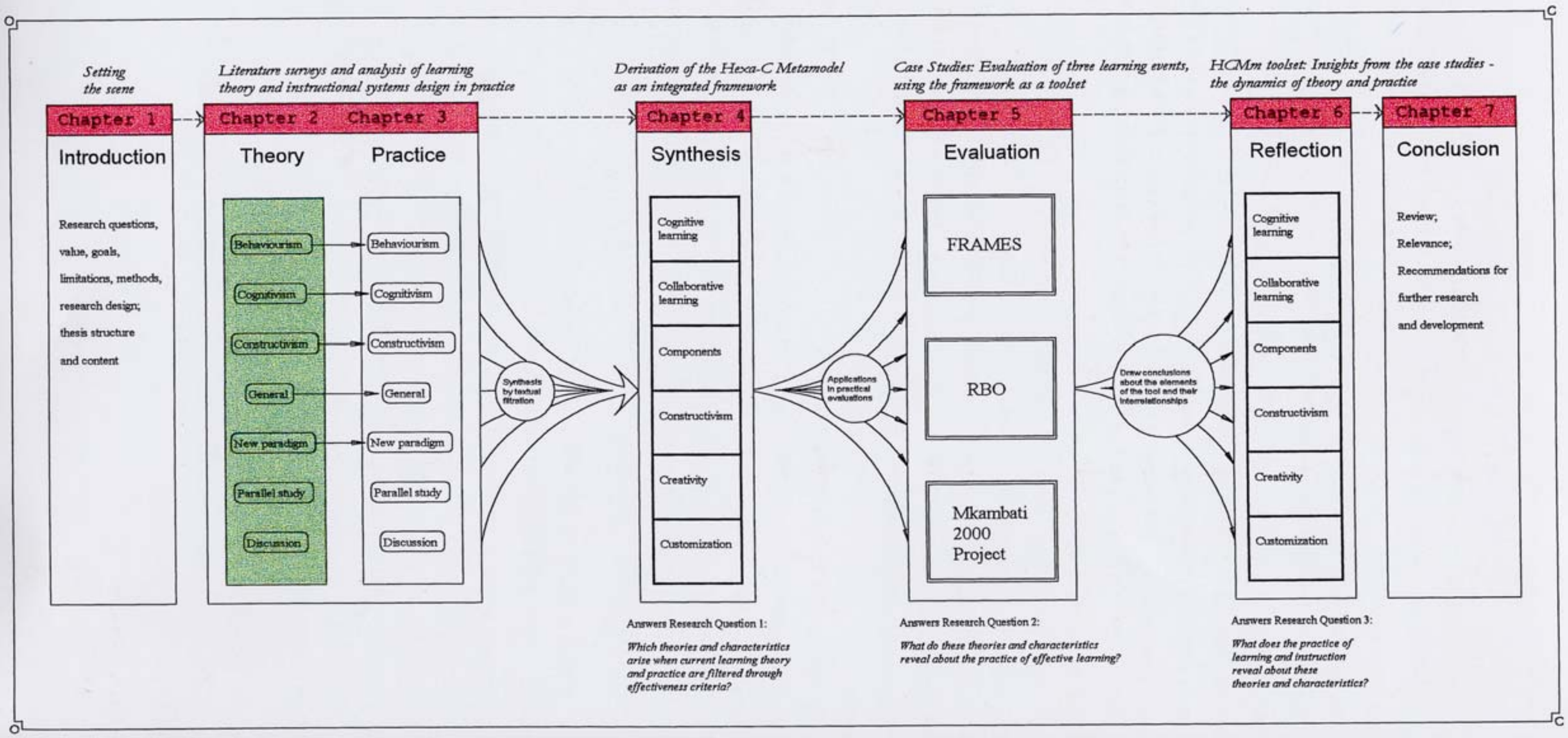
Structure of the thesis



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.

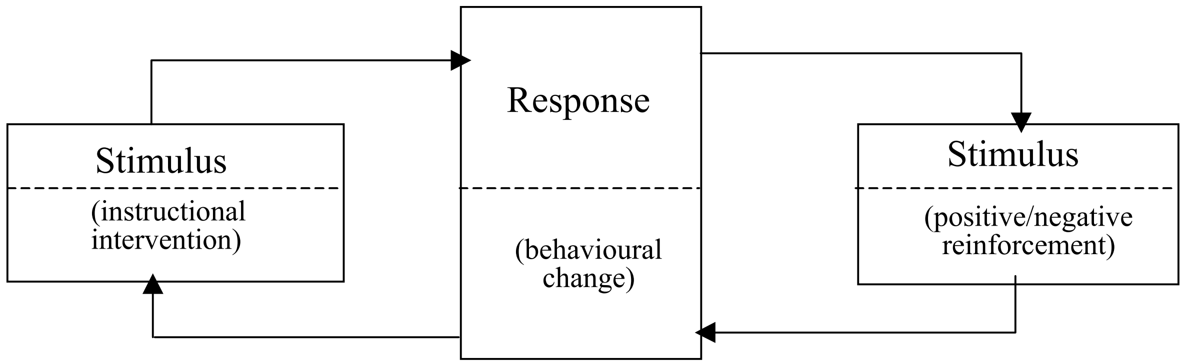
2.2.1 Background and ethos of behaviourist instructional theory

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:

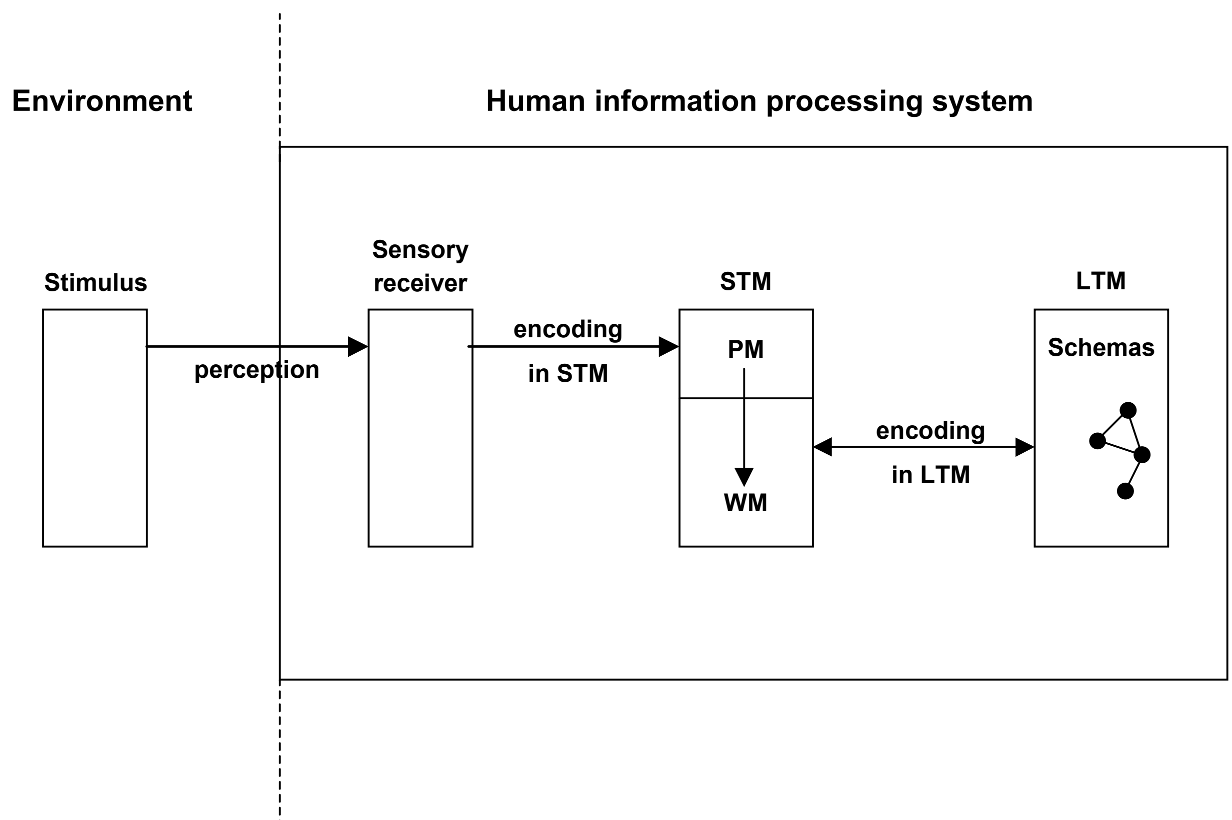
- Sensation from a stimulus,
- perception,
- encoding in STM,
- association,
- encoding in LTM, and
- retrieval.

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.

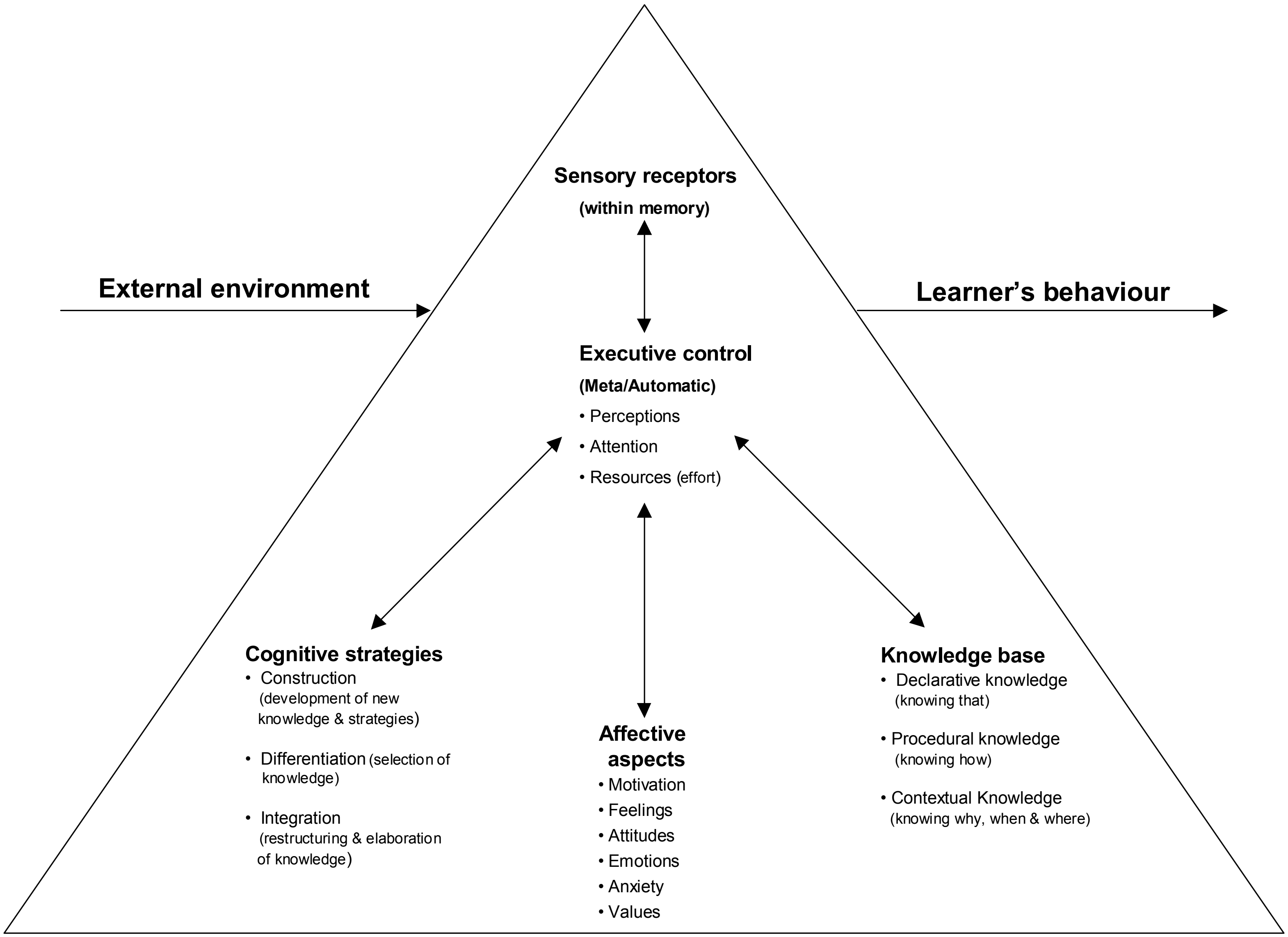
The three guidelines used for the interactive learning model are that it should contain:

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.

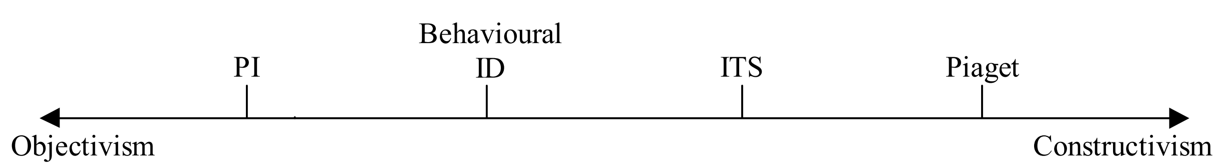
- According to Reigeluth (1989), all descriptive theories have some useful contribution to make. In proposing a new learning-focused paradigm, Reigeluth (1996c; 1999) suggests flexible guidelines for instructional situations, in the face of many disparate theories and models. Despite the new paradigm, 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.

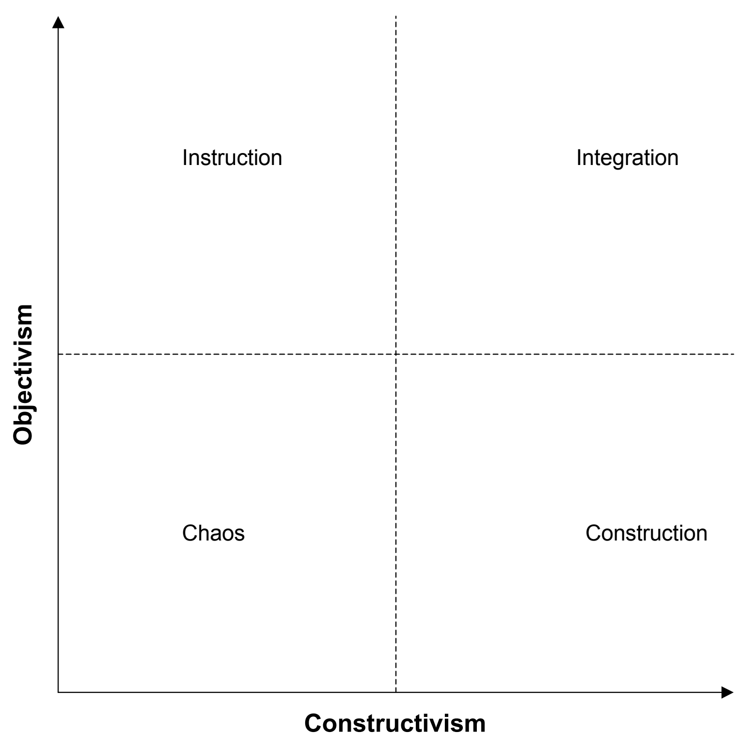
Figure 2.4 The objectivist-constructivist continuum

(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.