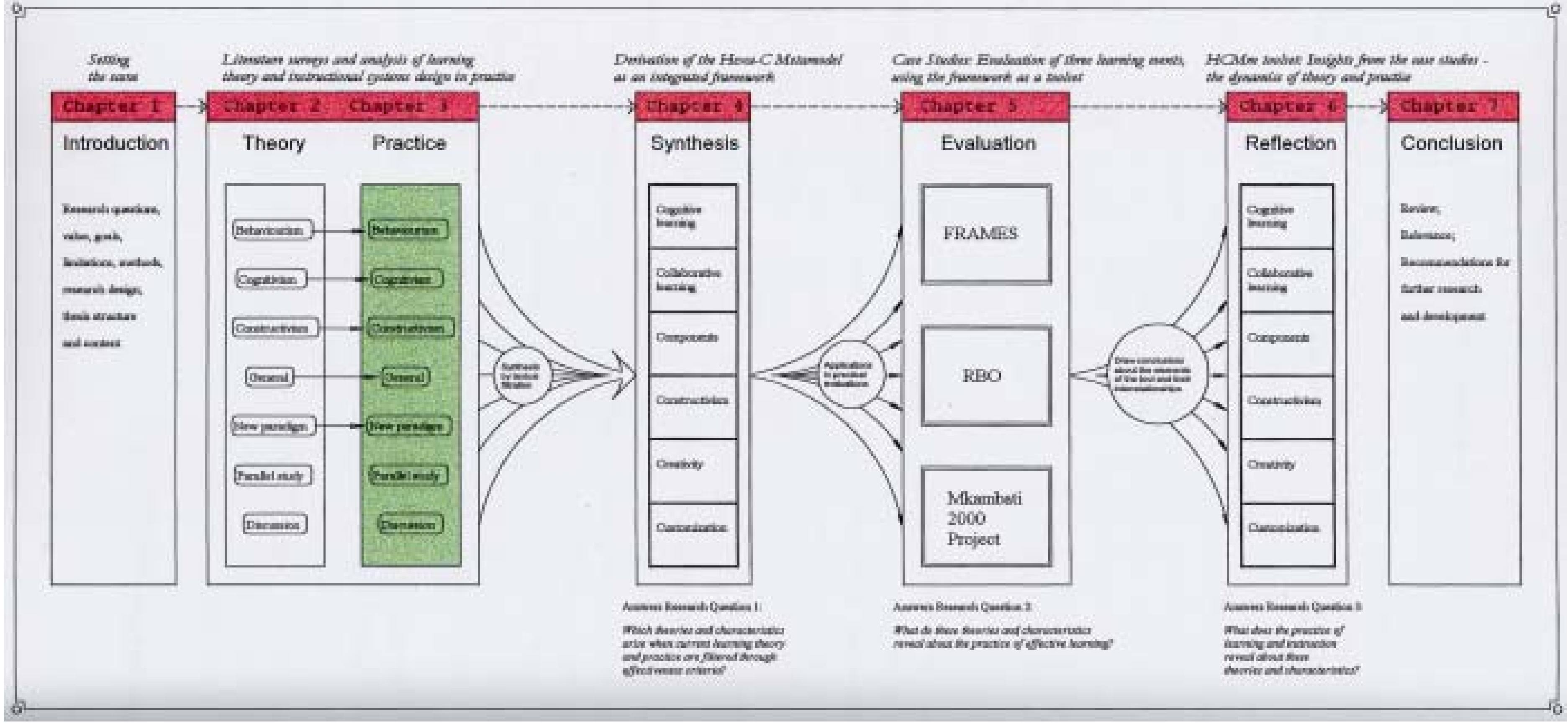
Structure of the thesis



Chapter Three

Practice

Learning and instructional systems design in practice

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

3.1 Introduction and discussion of terminology

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

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

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

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

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

3.1.1 Instruction and learning: theory to practice

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

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

Theory-technology relationship

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

3.1.2 Terminology

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

Descriptive and prescriptive theories

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

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

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

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

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

Table 3.1 Descriptive theories and prescriptive practices

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

Progression from theory to practice

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

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

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

Grounded design

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

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

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

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

3.2 Behaviourist instructional systems

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

3.2.1 Introduction to behavioural instructional systems development

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

Systematic linear procedures

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

Behaviourist bias

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

Who does what?

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

Delivery media

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

3.2.2 Characteristics of behaviourist instruction

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

3.2.2.1 Fleming and Levie's behaviourist principles

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

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

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

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

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

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

3.2.2.2 Hannafin and Peck's behaviourist principles

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

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

3.2.2.3 Gropper's behaviourist skills

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

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

3.2.3 Behavioural instructional systems development models

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

3.2.3.1 Gagné's events of instruction

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

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

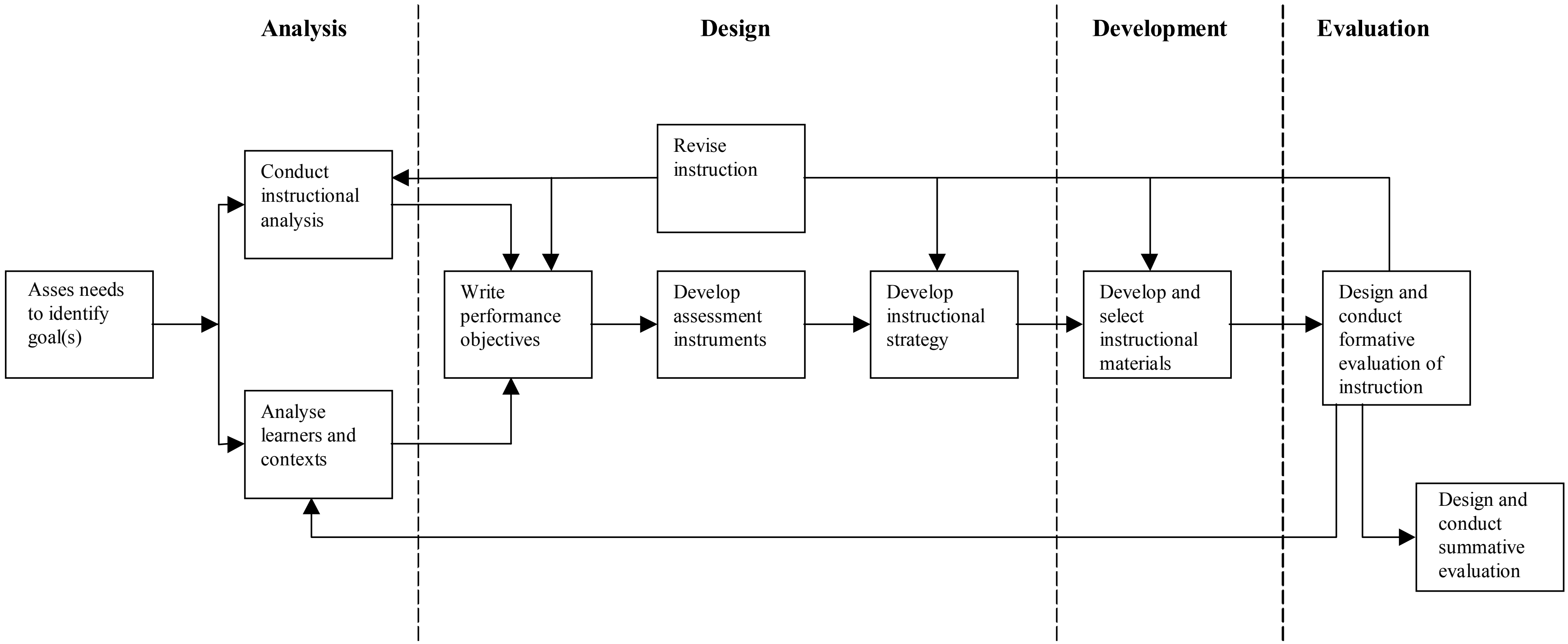
Not all of Gagné's instructional events are applicable to any given situation. Designers must select appropriate events and gear their concomitant procedures to the desired learning outcome/s.

3.2.3.2 The Dick and Carey model

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

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

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



3.2.3.3 The Briggs and Wager model

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

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

3.2.3.4 The Braden model

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

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

3.2.4 Discussion of behaviourist instructional design

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

CAI software

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

Objectivist design

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

Mastery

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

Reductionism

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

General

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

3.3 Cognitive instructional systems

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

3.3.1 Introduction to cognitive instruction and systems development

From behaviorism towards cognitivism ...

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

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

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

3.3.2 Characteristics of cognitive instructional design

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

3.3.2.1 Objectives and task analysis

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

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

3.3.2.2 Entry characteristics

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

3.3.2.3 Instructional strategies

1. Winn's comparison of traditional and cognitive strategies

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

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

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

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

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

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

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

2. Cognitive strategies

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

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

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

3.3.3 Cognitive ISD models

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

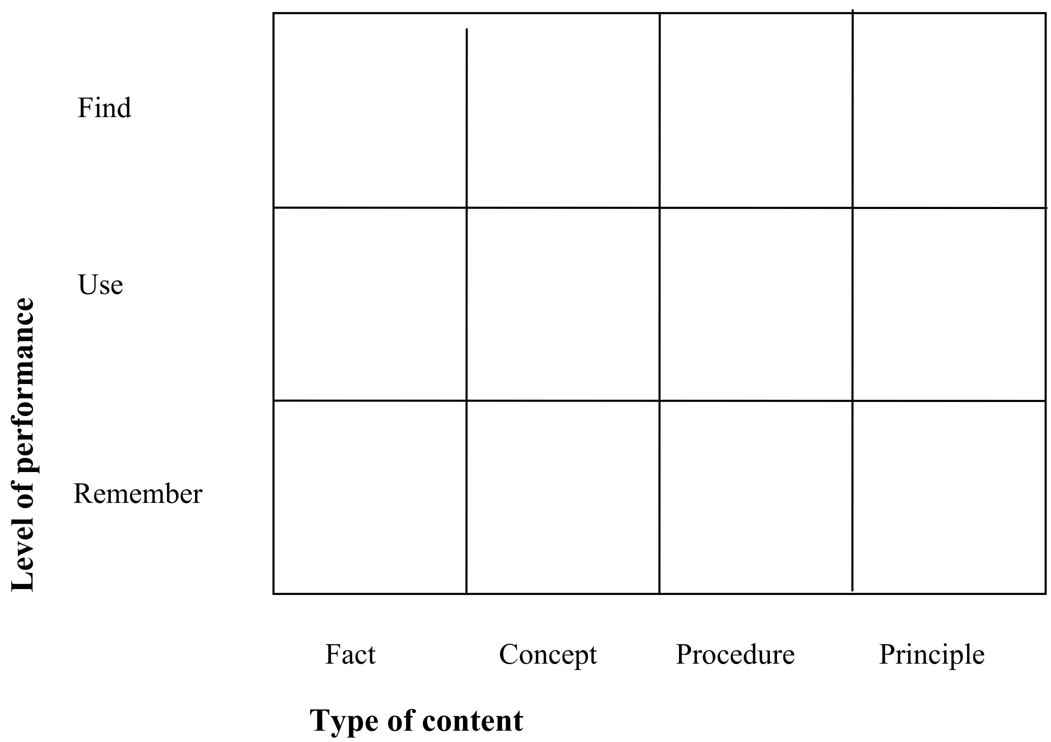
3.3.3.1 Component display theory (CDT)

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

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

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

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



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

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

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

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

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

3.3.3.2 Another perspective on components

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

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

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

3.3.3.3 Enterprise schemas

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

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

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

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

3.3.3.4 Second generation instructional design (ID_2)

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

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

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

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

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

There are three kinds of frames:

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

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

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

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

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

3.3.3.5 Instructional transaction theory (ITT)

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

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

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

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

3.3.3.6 Alternative views to linear ID - 'design alternatives'

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

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

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

3.3.4 Cognitive-related aspects: practical applications in ISD

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

3.3.4.1 Implementation of metacognitive strategies

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

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

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

3.3.4.2 Instructionism and grounded design

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

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

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

3.3.4.3 Five star instructional design rating

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

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

3.4 Constructivist instructional systems

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

3.4.1 Introduction to constructivist learning and constructivist design

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

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

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

3.4.1.1 Differences between assumptions of traditional ID and constructivism

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

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

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

2. *Different role for technology*

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

3. *Different approach to design*

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

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

3.4.1.2 Towards constructivist instructional design

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

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

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

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

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

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

5. *Evaluation*

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

3.4.2 Characteristics and principles of design for constructivist learning

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

3.4.2.1 From objectivist strategies to constructivist methods

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

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

3.4.2.2 Constructivist values

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

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

   This entails emphasizing the affective domain of learning and making instruction personally relevant, in line with Keller's ARCS model (see 2.5.3.2). In particular, instruction should be designed to achieve a balance between:
   - external control of the learning situation, and
   - promotion of self-regulation and personal autonomy among learners.

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

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

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

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

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

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

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

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

3.4.2.3 Constructivist constructs

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

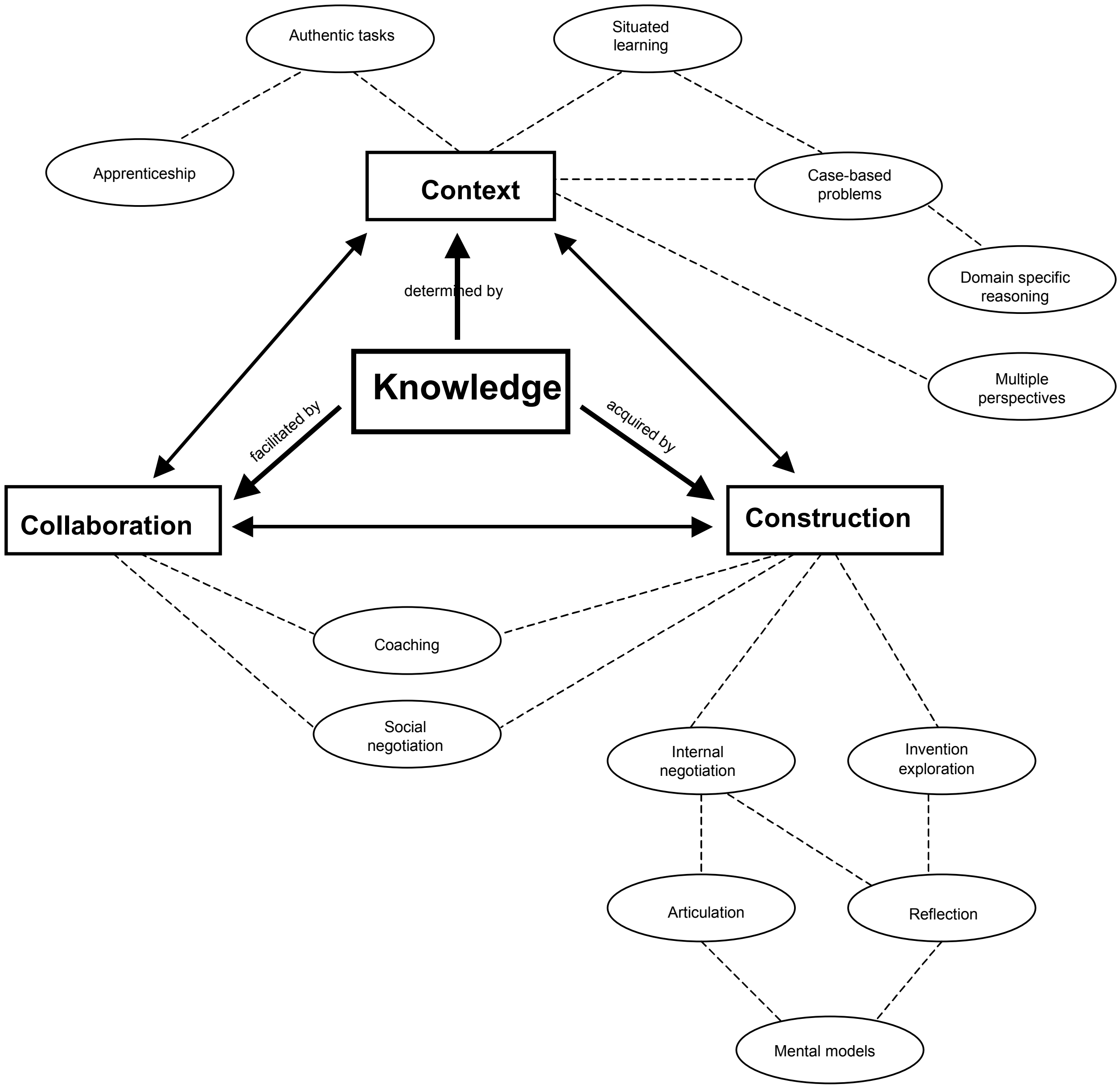
1. *Constructivist design should produce environments that support the construction of knowledge*. This knowledge is
   - based on internal negotiation by learners to produce and articulate their mental models, using them to explain, predict, and reflect;
   - supported by social negotiation; and
  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

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

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

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

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



3.4.2.4 Constructivist instructional principles

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

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

3.4.2.5 Constructivist design principles

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

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

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

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

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

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

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

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

3.4.2.6 BIG and WIG constructivism

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

3.4.2.7 Constructivist assessment

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

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

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

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

3.4.3.1 The recursive reflective design and development model (R2D2)

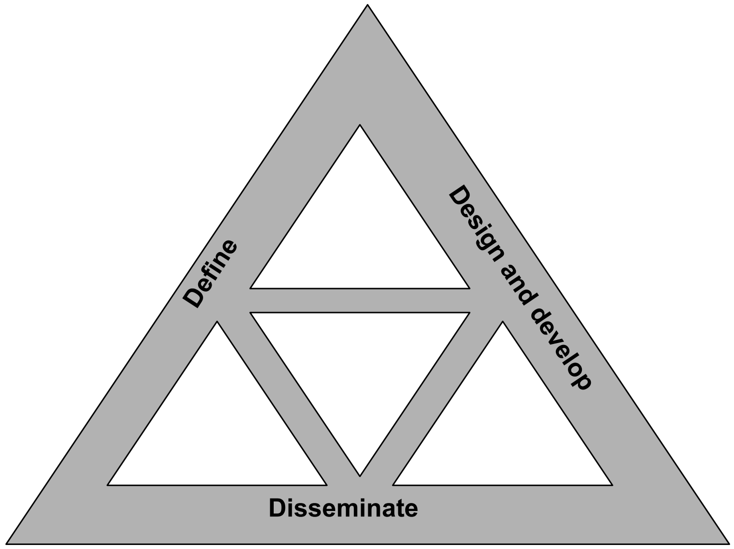
Willis (1995; 1998; 2000) who made well-formed suggestions in the Recursive, Reflective Design and Development (R2D2) model, is a pioneer of constructivist instructional design (C-ID).

The model

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

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

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



The perspectives:

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

The components (focus areas/points)

Definition focus:
This is based on the subtasks of the traditional ID model, but adapted:

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

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

Design and development focus:

In a traditional ID model, design tends to be completed before development (when the instructional material is actually created), but R2D2 combines the two processes into one focus area. This stage involves selection of media and format; selection of a development environment; product design and development; and evaluation strategy.

The R2D2 team do not believe that products with high user-appeal can be produced using a traditional, top-down, linear model of development. Merging the tasks of design and development reduces risk, because fundamental problems are discovered early, obviating committal to a design that cannot be properly executed. Another advantage is the opportunity for experimentation - running segments of the program with learners - and immediate revision, to see the effects of change. This enhances the quality of the end-product. In order to handle design and development in this recursive manner, an interactive development environment is required, so that the final format, content, and feel can emerge across the development process. Formative evaluation by learners, pilot-tryouts, as well as expert appraisal, are thus integral parts of design and development.

Dissemination:

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

3.4.3.2 The layers of negotiation model for designing constructivist learning materials

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

Assumptions of the model

Designing materials for constructivist learning environments implies that both the processes and the products of instructional design must be revised. Within this perspective, it is inappropriate to set learning objectives. So the authors aim to design materials guided by their assumptions about teaching and learning, and having done so, reflect over the design process and compare the procedures with those prescribed by traditional models. The three basic assumptions were that:

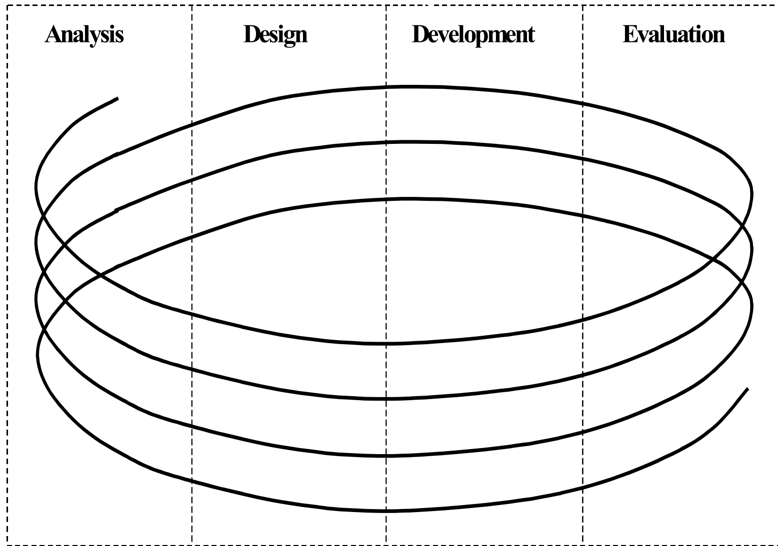
1. Learners come to an instructional setting from a wide variety of backgrounds that have shaped their understandings, beliefs and values. They derive individual meaning from an instructional experience as they mediate it through their unique filter of understanding. Learning materials must thus be capable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

Conditions to be incorporated within constructivist learning environments

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

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

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



Discussion

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

- *Process-based versus procedure-based design*

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

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

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

- *Spiral cycles instead of discrete stages*

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

3.4.3.3 Constructivism and grounded design

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

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

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

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

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

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

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

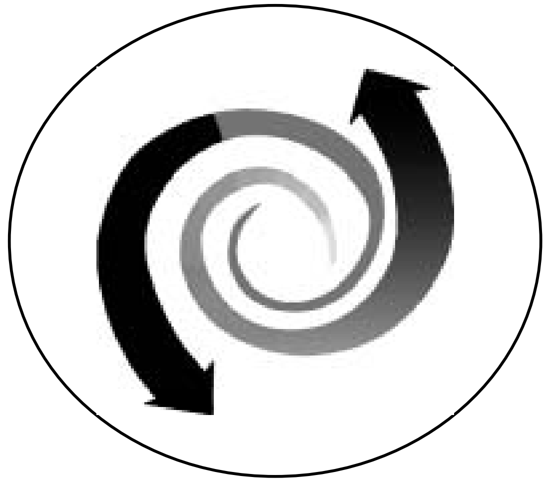
5. The tendency towards extreme constructivism can be mitigated when aiming *pragmatically* for a learning environment with an aligned, balanced foundation. Reasonable accommodations should be implemented, based on the unique features of each situation.

3.4.3.4 The revised R2D2 model

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

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

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



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

The components (focus points)

These were defined in section 3.4.3.1 and only salient issues are mentioned here.

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

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

Design and development focus

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

Dissemination focus

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

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

3.4.3.5 Activity theory as a framework for designing constructivist learning environments

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

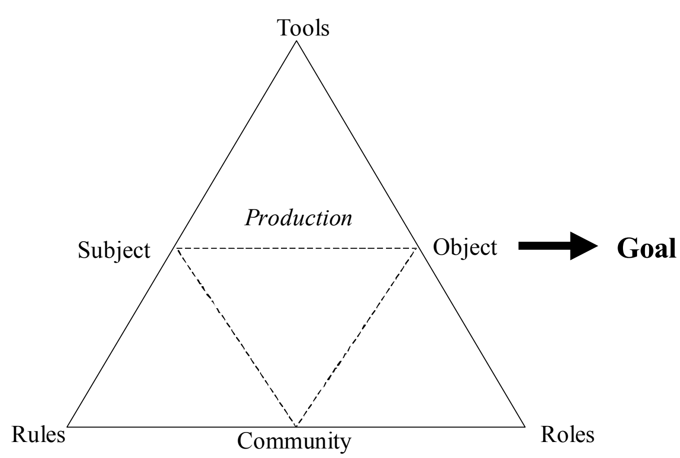
Activity theory

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

Activity systems

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

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



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

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

Assumptions of activity theory

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

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

Activity theory as a framework for designing CLEs

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

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

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

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

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

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

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

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

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

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

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

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

   Outcomes:

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

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

3.4.4 Design of learning in perspectives related to constructivism

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

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

3.4.4.1 Situated cognition, anchored instruction, and cognitive apprenticeship

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

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

3.4.4.2 Constructivist learning environments (CLEs)

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

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

Components and characteristics of a constructivist learning environment

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

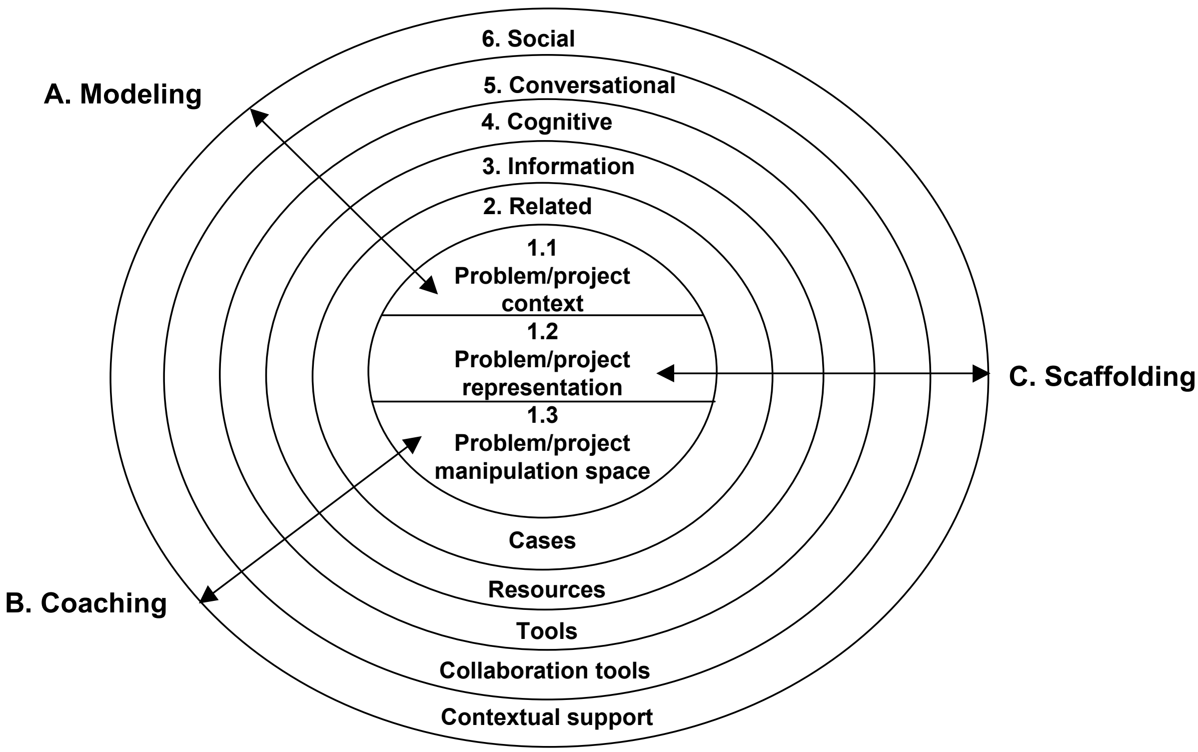
> *Students learn domain content in order to solve the problem, rather than solving the problem as an application of learning* (Jonassen 1999: 218).

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

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

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

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



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

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

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

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

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

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

3.4.4.3 Open-ended learning environments (OELEs)

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

Underlying assumptions in open-ended learning

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

1. *Context and experience are critical to understanding:*
   The process and the context of learning are inextricably tied. Knowledge detached from an authentic context is often inert knowledge which cannot be effectively employed or transferred across situations. OELEs aim to develop learning and problem solving from rich, concrete experience,

embedded in an authentic context. The environment provides a type of phenomenarium where learners can manipulate parameters, alter the level of complexity, and create their own resulting products, for example, models, maps, experiments, etc. Activities in an OELE can both converge on and diverge from the topic to provide multiple perspectives.

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

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

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

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

Characteristics of OELEs

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

Foundations and values of OELEs

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

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

Finally ...

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

3.4.4.4 Problem-based learning (PBL)

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

Problem generation

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

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

Problem presentation

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

Role of facilitator

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

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

3.4.4.5 Implications of chaos theory for instructional design

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

Paradoxes inherent in instructional design

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

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

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

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

How does chaos impact on ISD and technology?

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

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

Chaos theory and instructional systems development

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

1. *Linearity versus nonlinearity*

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

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

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

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

2. *Deterministic expected predictability versus indeterministic unpredictability*

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

3. *Closed versus open systems*

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

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

4. *Negative feedback loop versus positive feedback loop*

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

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

3.5 Cross-paradigms issues

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

3.5.1 Collaborative learning and co-operative learning

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

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

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

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

3.5.2 Learner-centricity, customization, and learner-control

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

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

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

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

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

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

3.5.3 Creativity and motivation in instructional methods and resources

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

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

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

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

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

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

3.5.4 Five facets of a learning environment

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

1. Information bank

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

2. Symbol pads

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

3. Construction kits

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

4. Phenomenaria

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

5. Task managers

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

3.5.5 Technology

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

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

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

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

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

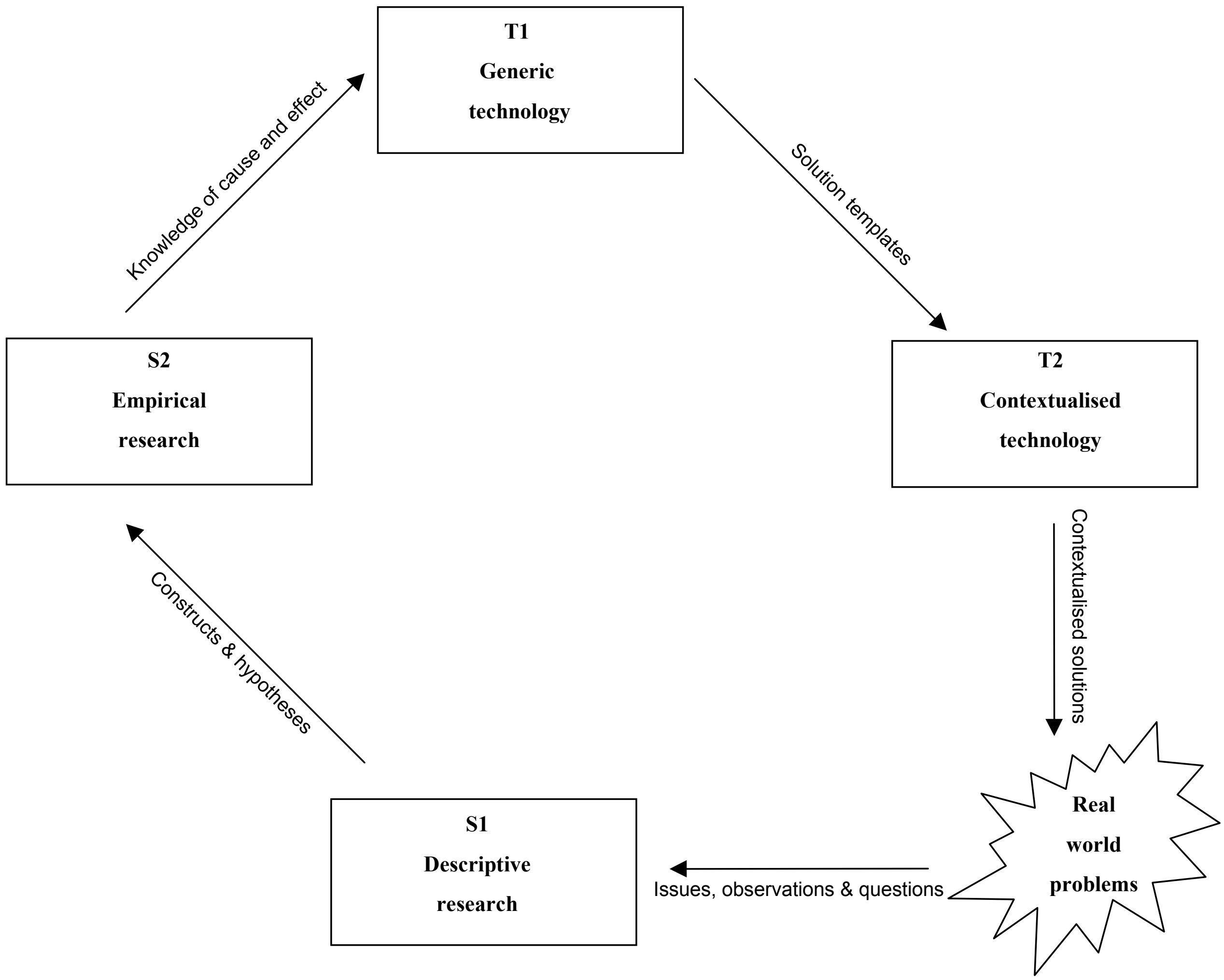
> *Technology is the application of scientific knowledge to human problems, and it includes a body of engineering methods and tools, related to, but distinct from, the tools and methods of science* (Estes & Clark, 1999:7).

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

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

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

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



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

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

3.6 The learning-focused paradigm of instructional-design theory

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

3.6.1 Towards a new paradigm

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

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

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

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

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

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

3.6.2 Reigeluth's classification according to instructional goal

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

1. Understanding

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

2. Problem-based learning

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

3. Community of learners

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

4. Higher-order thinking skills

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

5. *Single categories*

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

6. *Psychomotor domain*

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

7. *Affective domain*

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

3.6.3 Implications of the learning-focused paradigm

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

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

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

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

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

   The actual value in practice of using learners on teams for designing and creating educational software is described by Steyn (2001), who involved students in developing a simulation for electrical concepts. Furthermore, in Section 2.6.4, which introduces Reigeluth's concept of user-designers, mention is made of Vincini's (2001) participatory design methods. In aiming for:

   (i) user-centred design,
   (ii) a shift from behaviourist and cognitivist ID towards a constructivist approach, and
   (iii) incorporation of Reeves' (1999, cited in Vincini, 2001) *learner-centred design principles of learnability, usability, and understandability,*

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

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

3.6.4 The debate on the learning-focused paradigm

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.7.1 Many current theories - resulting confusion

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

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

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

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

3.7.2 Issues involved in building a full theory

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

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

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

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

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

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

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

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

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

What is instruction and what is instructional design?

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

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

3.7.3 How instruction can influence learning

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

1. Motivation

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

2. S*tructuring the learning situation*

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

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

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

Instruction - process or product?

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

3.7.4 Towards a theory of instructional design

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

1. *Determine the nature of learning and explicate it.*
   Set out one's own theory of learning explicitly.

2. *Characterize the interaction space leading to learning.*
   The interaction space is the intersection of the processes and products that engage the learner and shape the learning experience. Laying down a theory entails determining the components of this space and their interrelationships.

3. *Subjugate all content to the instructional function.*
   Instructional-design theory should not artificially motivate learners - the content should motivate.

4. *Keep out of curriculum decisions.*
   This is a societal decision, the territory of the educational stakeholders. Instructional designers must remain neutral, lest their theories become narrowly applicable.

5. *Attempt to devise rules of instruction.*
   Rules should be explicit, yet generally applicable. Forming rules is a heuristic exercise that can result in refinement of one's views, thus enhancing the theoretical base.

6. *Situate and confront.*
   Academic confrontation, comparative analyses, and positive criticism all form part of the sociology of theorizing and are integral parts of the process of scientific progress in all sciences of the artificial.

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

3.8 Instructional design approaches - eclectic and pure …

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

3.8.1 Should aspects of different paradigms be combined in ISD?

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

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

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

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

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

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

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

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

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

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

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

3.8.2 Research methods to examine different paradigms

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

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

3.8.3 The practitioner in action

Effective learning is also a function of the practice of instruction. Actual instruction requires a climate of some flexibility. Schön (1987:15) uses the term 'professional artistry' to describe the competence of practitioners (in this context, educators) who adeptly handle situations of uncertainty and uniqueness. This kind of skillful performance is sometimes instinctive, and cannot be precisely articulated, a phenomenon Schön (1987:26) refers to as 'reflection-in-action'. It implicitly questions assumptions and gives rise to on-the-spot experimentation. Yet spontaneous reactions may indirectly shape future action as practitioners consider their reflection-in-action and use it towards subsequent structured actions.

The distinction between the design of instruction and the practice of instruction is mentioned by Wilson (1999) in the context of grounded design. Wilson values grounded design in relation to the development of models/tools to facilitate instruction and learning – asserting that instructional designers should be informed by theory and deliberately apply some theory of learning. In respect of real-life instruction, he would not require the same level of consistency between a given theory and practice, accepting that teachers may take a practitioner-centred approach, trying perspectives eclectically. People, rather than ideologies, are in control and the needs of the situation dictate the rules and values.

3.9 Conclusion

This chapter is an extensive overview of learning and instructional systems and their development models. In investigates practical applications of the learning theories discussed in Chapter Two, and makes explicit that which is often tacit, namely the distinction between learning theory, instructional design, and instructional practice.

Design of instruction and the different paradigms

Instructional design processes should be adapted or transformed so as to remain relevant on the cutting edge. Traditional ISD models are suitable for many forms of *basic, direct instruction* and practice, but do not lend themselves to the creation of constructivist learning materials, where passive learning of content is replaced by problem solving and learner-initiative. *Constructivism*, as a broad theoretical framework, does not naturally give rise to systematic design models, nor does it always require formal, tangible learning materials. Rather, it yields learning philosophies as a foundation for ID and associated principles/guidelines, although there are situations where C-ID processes exist for the development of constructivist resources (e.g. the R2D2- and layers-of-negotiation models, and grounded design). Reigeluth's *new paradigm of learning-focused instructional theory* (Section 3.6.3; Reigeluth, 1996a; 1996c; 1999; Reigeluth & Squire, 1998), which has commonalities with constructivism, also has implications for ISD such as non-linear development and the involvement of users as designers. ID should be situation-specific and embedded in context (Hwang, 1996) and thus requires a continuous process of re-invention so as to meet changing requirements.

Direct instruction is likely to play a less major role in the 21st century than it has in the 20th century, therefore a serious need exists to have sound philosophies and procedures for development of resources and tools for the alternatives - problem-based learning and learner-centred environments such as CLEs and OELEs.

Can varying theories be integrated in the design of learning and instruction?
Can they even co-exist?

The present researcher promotes compatibility, complementarity, and a position of considered compromise, provided that the **positions have a cognitive grounding**.

- Direct instruction of basic knowledge can be enhanced by selected tenets of constructivism;
- Balanced constructivism holds challenging promise and is strongly related to learner-centricity;
- Designers should integrate aspects of the available theories and strategies, so as to synergistically optimize on compatible and complementary stances.

In applying theory to practice, different theoretical perspectives are appropriate for supporting different kinds of learning. Within in a major learning experience, there are different forms of knowledge and skills to be acquired, processes which are supported by different frameworks and practices. Learners seldom attain the skills to competently tackle complex problems, without first grasping basic lower-level skills. Each theoretical perspective and its associated implementations offer practices and tools that facilitate

- different kinds of learning
- among different kinds of learners
- at varying stages and in different parts of instruction.

Learning theory, instructional theory, and instructional practice

This chapter addresses the relationship between descriptive learning theories and prescriptive instructional-design theories. The study has identified a further demarcation – the distinction between instructional design and instructional practice. In the context of traditional ISD, all three facets are separately evident: underlying learning theories, an instructional design process, and presentation of instruction. In the more contemporary approaches and learning environments, distinctions blur as facets merge. In particular, there is less emphasis on instructional development as a separate process, since design and delivery of instruction may converge. *Instructor-designers* are emerging and the focus is on the provision of environments for active learning, rather than on predefined learning systems.

In conclusion …

Society in the early 21st century is characterized by social consciousness. The implication for education is that instruction and learning should not be addressed merely in a pragmatic manner but rooted in a value system. Educational practice has traditionally been founded on underlying values and philosophies, but implicitly so. The difference now is that values are made explicit and used by practitioners as the basis for decision-making.

Education, training and instruction are changing due to various factors. Technological advances open up new possibilities, and a democratic user-centric culture promotes the acquisition of life-skills along with content learning. Despite this, no learning theory or instructional approach can guarantee results, because the raw material of instruction is comprised of human learners with their varying backgrounds, values and biases, emotions, and abilities.

Chapter Four summarizes and analyses learning theories against certain criteria, and extracts a concise set of inter-related elements (theories and characteristics) which have utility for designing learning experiences, environments and events. The framework can also be used to evaluate existing learning events, and in a meta-manner, the more it reveals information about learning events, the more it reveals about its own elements. In other words, as **theory informs practice**, **so practice extends the theory.**