Computer Games as a Pedagogical Tool in Education

By

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Masters of Science in Computer Applications, is entirely my own work and has not been taken from the work of others save to the extent that such work has been cited and acknowledged within the text of my work.

Signed: Ken Maher. Date: 29/9/97

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"No one really cares whether PacMan gobbles up all those little spots on the screen. Indeed, as soon as the screen is cleared, the player covers it again with more little spots to be gobbled up. What is reinforcing is successful play, and in a well designed instructional program students gobble up their assignments."

(Skinner, 1984, p. 24)

Abstract

Designing computer based environments is never easy, especially when considering young learners. Traditionally, computer gaming has been seen as lacking in educational value, but rating highly in satisfaction and motivation. The objective of this dissertation is to look at elements of computer based learning and to ascertain how computer games can be included as a means of improving learning. Various theories are drawn together from psychology, instructional technology and computer gaming, to devise an effective strategy in designing computer-based tutoring systems. With the inclusion of gaming elements, various designs can be tailored to the specific learning criteria of the students, reflecting their competencies and failings. More specifically, certain games can facilitate learner effects such as immersion, reward, motivation, reflection, collaboration and feedback; all necessary for effective learning (Wynn & Oliver, 1996).

A taxonomy of the most common games in relation to their possible role in education is developed. The inclusion of gaming concepts is considered from both the behaviourist and constructivist views on instructional design. A model for the inclusion of various exogenous games into existing educational formats corresponding to Gagné's (1977) instructional events is defined. Exogenous games are those that employ extrinsic fantasies and that are independent of the courseware. Five insertion points for exogenous games are defined. These are; 1) the exogenous game as an engaging environment, 2) as an aid to presentation of information, 3) as a means of aiding the testing of information, 4) as a means of rewarding the student and 5) as a means of enhancing retention and transfer. The model is described in detail with reference to the effective use of computer games for educational purposes. It was found that the model has value in web-based instructional design and designing computer based learning environments for young students and those with special needs.

Chapter 1: Principles of Learning

1.1 Introduction

Designing Computer based educational packages is never an easy task. However, with the advent of multimedia applications and various authoring packages, the design of computer-based learning materials has become relatively easy for the common computer literate instructional designer. This means that teachers from many backgrounds can design their own educational packages and tailor the content to suit their needs.

Besides the design of the educational content, the designer must consider a number of other factors in the preparation of the computer program. Theories about instructional design have focused on the learner's internal capabilities (Cognitive theories), the reinforcement of target behaviours (Behaviourist theories), the construction of active meaning (Constructivist), and the motivation to learn (e.g., Malone, 1981). This dissertation looks at the realm of both instructional design and computer games design in an attempt to better understand how to design effective educational software.

The objective of this dissertation is to look at the domain of computer-based learning and ascertain how computer games can be included in the learning process as a means of improving motivation and learning.

Three aspects of learning are considered in Chapter 1. Firstly, the Cognitive Psychology perspective on the learning processes is given. The acquisition of new information is seen as a process of taking incoming information and fitting it with existing cognitive structures (or Schemata). Secondly, the behaviourist view of learning sees the process as an acquisition of a target behaviour from a series of contingent rewards (Skinner, 1957). Thirdly, Motivation is looked at as a primary mechanism for getting and sustaining attention for any learning task. A theory of intrinsically motivating instruction (Malone, 1981), developed from studies with computer games, is discussed in detail.

In Chapter 2, theories on Instructional Design and Multimedia are outlined. Firstly, Gagné's (1977) instructional events and learning outcomes are discussed in light of the design of educational material. Various methods of delivering computer-based instruction are presented. These include tutorials, drill and practice software, simulations and games. Developments in the field of Multimedia and Hypermedia are discussed with reference to theories of learning such as the Mastery learning model (Carroll, 1963), the ARCS model of motivation (Keller, 1987) and a model considering the affective domain in (IMM) Interactive multimedia (Wynn & Oliver, 1996).

In Chapter 3, considerations for designing successful and compelling games are outlined. The core elements of games are discussed with respect to relevant psychological theories. For the purposes of better understanding the potential use of different computer games in the design of educational materials, a taxonomy of games is developed. The last section of chapter 3 looks at educational effectiveness of games as a method of learning. In addition, a new term for the types of games most suited to inclusion into existing CAI (Computer Assisted Instruction) software is proposed based on previous research.

In Chapter 4, a model is proposed for insertion of the newly defined exogenous games into existing instructional formats based on Gagné's (1977) instructional events. Examples of exogenous games are given for each of the insertion points mentioned in the proposed model.

In Chapter 5 a discussion of the various learning environments is undertaken with reference to the gaming content as a consideration within education for learner's of all ages. The limitations of the proposed model are also highlighted. The potential for games and future directions for research are suggested.

1.2 Theories of Learning

To better understand the pedagogical attributes of computer gaming it is first necessary to identify some learning concepts. Learning can occur in almost any context, with some learning being unconscious. In this chapter, concepts of learning from two main schools of Psychology (Cognitive and Behaviourist Theories) are outlined and motivation is considered as a primary mechanism for sustaining learning of new material (e.g., Malone, 1981).

Learning has been described as "the process of acquiring relatively permanent change in understanding, attitude, knowledge, information, and skill through experience" (Wittrock, 1977, p ix). The acquisition of knowledge can occur in almost any context, and learned material can remain with us from minutes to decades. Good & Brophy (1995), outline some qualitative distinctions between different types of learning by considering learning under various dichotomies. These include: knowledge that vs. knowledge how; intentional vs. incidental learning; rote vs. meaningful learning; and reception vs. discovery learning.

Knowledge can be *declarative* or *procedural* (Good & Brophy, 1995). *Declarative* or propositional knowledge, is knowledge that contains facts, concepts, or generalisations. It may be the memory of an event, a rule of trigonometry, or telephone number. Therefore, it covers both semantic and episodic memory. *Procedural* knowledge corresponds to 'knowing how', and refers to the ability to perform skilled actions without the involvement of conscious recollection. The ability to ride a bicycle is therefore termed *procedural* knowledge. Learning involves both declarative and procedural knowledge and the ability to perform a task may depend on how well both types of knowledge are integrated together.

Learning is considered to be either *intentional* or *incidental* (Good & Brophy, 1995). *Intentional learning* is a direct conscious process which is goal directed. A person sets out with the intention of learning something. *Incidental learning* is learning that is not consciously decided upon. It is a by-product of performing a task. A person may perform one task and inadvertently learn another skill. Thus, learning becomes a relatively passive experience with the person learning from the environment, but without specific goals.

New information is often learned with no reference to previous knowledge. *Rote learning* is the process of merely learning material without relating it to what is already acquired. If however, the incoming information is checked with what is already known, it becomes meaningful. The process of constructing coherent understandings of content is referred to as *meaningful learning* (Good & Brophy, 1995). *Meaningful learning* is retained longer than rote learning and is often necessary for understanding new concepts. Piaget (1970), considered children's cognitive development as the process of seeking an equilibrium between what they perceive, know, and understand on one hand, and what they see in any new phenomenon, experience, or problem on the other (Gage & Berlinger, 1991). If the new information being learned does not conflict with previous knowledge, there is no effect on the equilibrium. However, if there exists some conflicting information, there needs to be some cognitive work done to restore the equilibrium. Piaget considered this 'adaptation' to take two forms, assimilation and accommodation, which occur simultaneously. Assimilation is the process of changing incoming information to fit existing cognitive structures. If the incoming information conflicts with existing cognitive schemata, their composition may change to fit the perceived information. This process is known as accommodation. Furthermore, if the information already stored affects future learning, there exists some transfer of existing knowledge to what is newly acquired. This transfer of learning can be either positive or negative. Positive transfer occurs when new learning is aided by something previously learned. Negative transfer occurs when prior knowledge makes learning more difficult.

Reception learning is considered as the learning of material that is presented in its final format and then elaborated for full comprehension. Therefore, all relevant information is given to the individual to learn and understand. *Discovery learning* refers to the acquisition of information by exposure to experiences or guidance which leads to the discovery of a target concept or goal. Learning is facilitated by providing structured pieces of information that the individual uses to understand the key insight.

1.2.1 Cognitive / Constructivist Theories

Cognitive Psychologists consider learning to be the active construction of meaning in the mind for information presented to the individual. They stress learning as the transfer of information from a short term store into long term memory. This process has become known as the multi-store model of information processing. Incoming stimuli are received into the brain through the sensory pathways and then transferred to the short term sensory stores (STSS). There exists a store for each sensory modality. The capacity of these sensory stores is probably indefinite, but information is held for only a brief period. If the information is given attention, it is converted to the short term memory store (STM) and working memory (WM). The STM has a small capacity for information (approximately seven chunks; Miller, 1957). With rehearsal, the information is encoded into the long term memory store (LTM) where it is retained for an indefinite amount of time. The LTM has an unlimited capacity for information, but is prone to interference.

Interference effects occur when knowledge is affected by previous or subsequent learning (Underwood, 1983). Interference can occur when information stored is altered to adjust to new information (known as proactive interference) or, when later learning interferes with what is previously learned (known as retroactive interference). Therefore, while memory is stored for a long period of time, the contents of a particular event can change or be altered over time.

A commonly accepted theory is that 'practice makes perfect'. It is one of the few laws in cognitive psychology: The Power Law of Practice. It states that if 'time on task' and 'number of attempts' were graphed on log-log co-ordinate axes, a straight line would result (Fitts & Posner, 1967). Thus, with practice, memory for learned material is increased and performance becomes almost automatic. After initially acquiring declarative or procedural knowledge, practice can incur some additional changes. These are outlined by Neves and Anderson (1981) as: (1) composition, which includes the combining of rule parts (declarative knowledge) into larger structures, and increased speed of performance; and (2) the attainment of automaticity, therefore reducing the demands on attention (Shiffrin and Schneider, 1977).

1.2.2 Cognitive Strategies

The next three sections outline the major components affecting the learning of new information (or skills) from the Cognitive perspective. Firstly, cognitive strategies are discussed with reference to how they increase the individual's learning capabilities. Secondly, the effects of learning on mental models are outlined and finally, learning styles are discussed in light of their effect on learning.

Certain skills can improve the learning ability and overcome some of the constraints of the information encoding process. 'Chunking' (or aggregation) is one such example (Miller, 1957). Chunking refers to the ability to gather information together, forming a new mass. This overcomes the limits of the STM by increasing the size of the chunks. Hence, more information can be manipulated during a task to reduce the time needed to complete it.

An example of 'chunking' by experts was demonstrated by Chase and Simon (1973). In their studies of grand-master chess players, they found them to possess a greater memory for a chess scenario on a chessboard than novices. They were able to 'chunk' the relevant information and remember it more easily than the novices. Their superiority was significant when the pieces were placed in some meaningful way, but not however, when they were randomly arranged. Therefore, while experts possess a greater ability to remember, it is specific to their domain of expertise only. Green and Gilhooly (1992) in a summary of expertise research, show experts to :

- Remember better.
- Use different problem solving techniques (tend to work forwards).
- Have better and more sophisticated representations of problems.

- Possess increased ability to perform better due to knowledge and not some inherent ability.
- Become experts through extensive practice.

Gagné and Glaser (1987) outline three types of cognitive strategies. (1) Learning strategies can be used to control or modify incoming information. In reading a selection of text, the reader can focus on particular keywords in order to understand the content quickly. Strategies for encoding and organising information can be taught (e.g., drawing a diagram) in order to improve learning. (2) Strategies for remembering can be linked with the encoding of information. For example, by associating objects with certain words, their speed of recollection can be increased. (3) Problem Solving strategies are used by individuals to solve puzzles. For example, in a means-end analysis the individual would note the goal state, the initial state, and create some intermediate state to reduce the difference. Then an operator would be selected to solve this subgoal (Newell and Simon, 1972). People approach tasks or problems with many preconceptions of what is involved. They are said to have a mental model of how it works. The next section looks more closely at how mental models can be considered when learning new information.

1.2.3 Mental Models

Mental models are useful ways of thinking about the world and how things work in general. Johnson-Laird (1983) considered mental models as the basic structure of cognition: "It is now plausible to suppose that mental models play a central and unifying role in representing objects, states of affairs, sequences of events, the way the world is, and the social and psychological actions of daily life." (p397). When people first try to understand a phenomenon, they use their existing models often unsuccessfully. However, with some learning, the models become more efficient and flexible. If a task is performed numerous times, a mental model of approaching the same task will be developed. However, if the task is changed, the corresponding mental model must be revised and adapted to suit. McCloskey (1983) found that people, even without training, possess naive theories of physical phenomena. For instruction purposes, various methods of teaching include identifying naive models brought to the beginning of a task, tracing the development of models from novice to expert, taking advantage of existing models and building on them, and teaching explicitly mental models that facilitate performance.

Other Cognitive skills include the use of mental operations to perform various tasks. These include mental imagery and mental mapping. The use of *Mental imagery* in education has been well documented as improving memory of learned material, especially for sport training (Moran, 1993). Moran found athletes to have significantly higher mental abilities in controlling mental images than non-athletes. They use mental imagery to enhance performance by practicing movements or strategies in their mind. Mental mapping involves the complex use of imagery to envisage maps and particular routes in the mind. Thus, the use of mental imagery aids the acquisition and performance of both cognitive and physical skills.

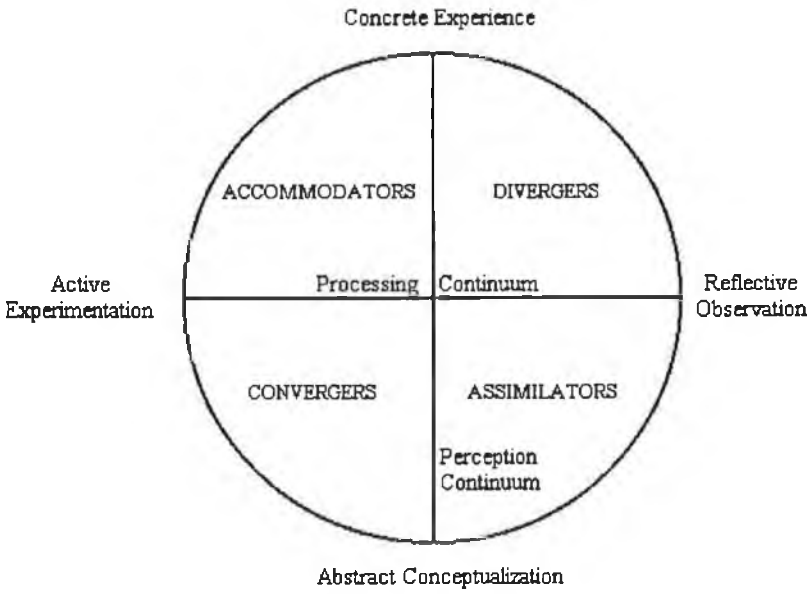
1.2.4 Learning Styles

Another important consideration when designing environments for learning involves the internal ways in which students learn. Just as people have different traits of personality, they also have different learning styles. They possess characteristic strengths and preferences in the ways they take in and process information (Felder, 1996). One of the most common ways people learn something new is by listening to someone talk about the information. Some people prefer to read about a concept to learn it; others need to see a demonstration of the concept. Litzinger & Osif (1992) describe learning styles as "the different ways in which children and adults think and learn (p73)." They see that each of us develops a preferred and consistent set of behaviours or approaches to learning. In order to better understand learning, they break it down into several processes:

1.*Cognition*--how one acquires knowledge.
2.*Conceptualization*--how one processes information (e.g., making connections to previously learned information).
3.*Affective*--people's motivation, decision making styles, values and emotional preferences will also help to define their learning styles.

A number of people have tried to catalogue the ranges of learning styles in more detail than this. Various learning style models have been developed (see Felder, 1996, for a review). Kolb (1984) is perhaps one of the best known and his thinking is outlined below.

Kolb (1984) showed that people have preferences for learning when taking in information (concrete experience or abstract conceptualisation) and how they internalise information (reflective observation or active experimentation) (Felder, 1996). The four dominant types of learning styles that occur most frequently according to Kolb (1984) are accommodator, assimilator, converger, and diverger. The optimum learning effect is achieved if one disposes of all four learning abilities. In reality we have a tendency to emphasise on one or two styles of learning. See Figure 1.1.



Kolb's Learning Styles

Figure 1.1 Kolb’s Learning Styles: from Litzinger and Osif (1992, p. 79)

Accommodators (Concrete experience/Active experimenter) are motivated by asking themselves the question "*what if?*". They look for significance in the learning experience and consider what they can do, as well as what others have done previously. These learners handle complexity well and are able to see relationships among aspects of a system. A variety of methods are suitable for this learning style, but anything that encourages independent discovery is probably the most desirable. Accommodators prefer to be active participants in their learning. The instructors working with this type of student might expect devil's advocate type questions, such as "What if?" and "Why not?"

Assimilators (Abstract conceptualisation/Reflective observer) are motivated to answer the question, "*what is there to know?*". They like accurate, organised delivery of information and they tend to respect the knowledge of the expert. They aren't that comfortable randomly exploring a system and they like to get the 'right' answer to the problem. Instructional methods that suit Assimilators include: lecture method (or video/audio presentation)--followed by a demonstration exploration of a subject in a lab, following a prepared tutorial (which they will probably stick to quite closely) and for which answers should be provided. These learners are perhaps less 'instructor intensive' than some other learning styles. They will carefully follow prepared exercises, provided a resource person is clearly available and able to answer questions.

Convergers (abstract conceptualization/active experimenter) usually ask the question "*how?*". The usefulness of the information gained is increased by understanding detailed information about the system's operation. Instructional methods that suit Convergers include an interactive session, whereby they can explore and understand concepts by trial and error. Here the instructor should act as a coach, providing guided practice and learning.

Divergers (concrete/reflective learners) are motivated to discover the relevancy or "why" of a situation. They like to reason from concrete specific information and to explore what a system has to offer and they prefer to have information presented to them in a detailed, systematic, reasoned manner. Instructional methods that suit Divergers include a lecture method, focusing on specifics such as the strengths, weaknesses and uses of a system. The instructor can assume the role of a motivator and facilitator for this category. Flexibility and the ability to think on your feet are assets when working with Divergers.

Hartman (1995) took Kolb's learning styles and gave examples of how one might teach to each them:

1. For the concrete experiencer offer laboratories, field work, observations or trigger films
2. For the reflective observer use logs, journals or brainstorming
3. For the abstract conceptualiser lectures, papers and analogies work well
4. For the active experimenter offer simulations, case studies and homework

Although Kolb (1984) thought of these learning styles as a continuum that one moves through over time, usually people come to prefer, and rely on, one style above the others. It is these main styles that instructors need to be aware of when creating instructional materials.

Cognitive theories look at how the individual would assimilate newly acquired information when learning (Piaget, 1950). Another way of looking at learning is to consider the behaviour of the individual and how it changes when learning occurs. This can be observed as a change in behaviour and the Behaviourist view of learning is outlined below.

1.3 Behaviourist View of Learning

Behaviourist psychologists stress reinforcement as the primary mechanism for establishing and maintaining behaviour (Good & Brophy, 1995). *Reinforcement* is the process of presenting a reinforcing stimulus to an organism after the organism has made a response. This results in an increase in the strength of that class of responses (Gage & Berlinger, 1991). B.F. Skinner demonstrated this idea remarkably well with rats in what has become known as the "Skinner box". A Skinner box is a cage containing a lever which a rat can push, and a small dispenser for food. When a novice rat is placed in the cage it roams about until it presses the lever by accident, or out of sheer boredom. However, if food is dispensed to the rat as a result, the rat quickly learns that if the lever is pressed, it will receive food. This effect is known as operant conditioning (Skinner, 1953). Thus, the rats behaviour is reinforced by the delivery of food (the reinforcer). Eventually the rat will be conditioned to press the lever continuously in order to receive food. This is analogous to what Loftus & Loftus (1983) describe as humans being in front of the "video parlour box", i.e. the reinforcements gained from the video game (see Chapter 3.1.2) maintains the interest of the game-player.

1.3.1 Types of Reinforcement

Certain events must be experienced contiguously by the learner in order for learning to occur. The event is reinforced only if the reinforcer is nearly-simultaneous to the performed action. Thus, when the action is remembered, so too is the reinforcement which followed. *Reinforcement* can be either positive or negative. A positive reinforcer could be food. An example of negative reinforcer would be an electric shock. If the number of lever-presses is increased for the rat in order to receive food, it will continue to press the lever. The rat receives food only after a certain amount of lever pressing. This is what is known as *partial-reinforcement.* The reinforcement is not continuous, but the anticipation of a reinforcement maintains the behaviour. *Frustration* occurs when the reward obtained is less than the expected reward. In this example the rat will become agitated if the amount of food is decreased. *Persistence* is activated after a history of reinforcements and non-reinforcements. It increases when the expectation of reward is no longer frustrated. If the rat does not receive food after pressing the lever, it will continue, but slow down and eventually stop. This decline in stimulus responding is what is known as *Extinction.* Therefore, with partial reinforcement, the target behaviour increases and leads to a greater resilience to extinction (Ferster & Skinner, 1957).

The scheduling of *partial-reinforcement* is important in maintaining the target behaviour. For example, a poker machine would only have a good hand once in a few turns. But the anticipation of a winning hand would be sufficient to keep on playing. Ferster & Skinner (1957) found variable schedules of partial reinforcement lead to the longest extinction periods. Variable schedules can take two forms, a variable ratio schedule such as reinforcement once every five turns or a variable interval schedule such as reinforcement once every minute. The application of behaviourist thinking in the design of computer games is discussed in Chapter 3.

1.4 Motivation

Motivation embraces many concepts such as needs, interests, values, attitudes, aspirations and desires. Our need to satisfy these concepts serves as our motivation (Gage & Berlinger, 1991). Motivation is goal orientated. A person strives to achieve something and feels much happier when successful.

Motivation may be *intrinsic* or *extrinsic* (Malone, 1981). Extrinsic motivation is considered to be external influences determining the person's behaviour. If, for example, a child receives a sweet for completing a task, he or she receives an extrinsic reward. If the child enjoys doing the task, then is said that the child has some intrinsic motivation. Developmental psychologist Piaget believed intrinsic motivation is needed for deep learning (Piaget, 1951). Further studies on intrinsic motivation determined that important skills are developed, such as learning how to learn (Shulman & Keislar, 1966). Individuals who have intrinsic motivation when doing a task have less need for extrinsic reinforcers. However, for students with little intrinsic motivation in a given task (e.g. learning some maths), providing another more intrinsically motivating task as a reinforcer can aid in the overall interest and motivation. This is what is known as the Premack principle.

The Premack Principle implies that what children do on their own initiative can be used as reinforcers for tasks which are less preferred (Premack, 1965). Children enjoy playing games and find them intrinsically motivating. A gaming format or elements of the game which are intrinsically motivating can therefore be used to facilitate both extrinsic and intrinsic reinforcement to persist on a computer based task. It is suggested how this may be facilitated in Chapter 4.

1.5 Malone's Theory of Intrinsically Motivating Instruction

Probably the most influential work in the field of instructional game design was done by Malone (1980, 1981). Based on his studies of highly motivating computer games, Malone (1981) developed a *Theory of Intrinsically Motivating Instruction.* This theory was based on three categories: *challenge, curiosity*, and *fantasy.*[1] Many researchers have used Malone's theory in developing new theories in instructional design and interactive multimedia (IMM) (Lepper & Chabay, 1992; Westrom & Shaban, 1992; Wynn & Oliver, 1996).

Malone (1980) found that in order for a game to be challenging it must provide goals whose attainment is uncertain. The game must be personally meaningful. The person playing the game must be able to identify and understand what is expected in the game. The goals can be fixed or emergent. Fixed goals are obvious, in that they are predetermined by cultural convention (Csikszentmihalyi, 1975). Emergent goals are seen in computer programs such as LOGO (Papert, 1980) or drawing packages. The goals would be determined by the user and would be seen at the end-product stage. Malone (1981) argues that in order to be motivated by a certain goal, the user needs some performance feedback to understand if the goal has been achieved.

1.5.1 Challenge

Malone (1981) found that the uncertainty of outcome is necessary in order for the game to be challenging. He outlines four general ways in which the goals can be made uncertain. Firstly, most games have *variable difficulty levels.* These can be automatically determined by the game, chosen by the user, or determined by the opponents skill. Secondly, there may exist *multiple level goals.* These can be of the same type repeated during the game, which vary in difficulty, or the use of problem solving skills in order to attain these goals faster or more efficiently. *Hidden information* constitutes another challenge to the game-player. Finally, *randomness* is included to make the attainment of

[1] It is important to note, however, that Malone's theory was based on what made games fun and not what made them educational.

goals uncertain. Randomness is facilitated by varying partial reinforcements and thus, increase the desire to persist (Ferster and Skinner, 1957).

1.5.2 Fantasy

The element of *fantasy* can be included in games to increase motivation and is defined as "mental images of things not present to the senses or within the actual experience of the person involved" (Malone, 1981, p.360). Fantasies can be induced when the game calls for use of mental representations such as visual imagery (this can be auditory also) in order to solve problems during the game. Malone (1981) outlines both extrinsic and intrinsic fantasies. *Extrinsic fantasies* are those that depend on the use of a skill but not vice versa. The user's input has an effect on the fantasy provided by the computer (e.g., HANGMAN). *Intrinsic fantasies* depend on the use of a skill and the skill being dependent on the use of the fantasy. (e.g., TETRIS). Malone (1981, p.361) based on one research study claims that "in general, intrinsic fantasies are both (a) more interesting and (b) more instructional than extrinsic fantasies". A further elaboration of the fantasy elements of games in given in Chapter 3.

1.5.3 Curiosity

Continued playing of a game depends on the degree to which game components can continue to arouse and satisfy one's curiosity (Malone, 1981). Malone distinguishes between *sensory curiosity* (the attractive, attention sustaining, audio-visual effects on screen) and *cognitive curiosity* (the "desire to bring better "form" to one's knowledge structures"; p363). In trying to resolve *cognitive curiosity*, the individual aims to bring completeness, consistency and parsimony to formed knowledge structures (or schemata). Malone also states that the informative feedback given to the player must be surprising (to maintain the player's interest) and constructive (to be educational). Constructive feedback should help them see how to change their schemata.

This chapter has shown how researchers from two disciplines (Cognitive and Behaviourist) view the learning process. Motivation is also seen as the primary consideration for the design of instructional environments (Malone, 1980, 1981). Malone's theory as outlined above has formed the basis for many subsequent theories of instructional and computer-game design. Theories of instructional design look at how learning is best supported. They can be either be prescriptive or descriptive. "Descriptive principles and theories take sets of conditions and methods as givens (constants) and describe the likely outcomes as variables of interest. In contrast, prescriptive principles and theories take sets of conditions and desired outcomes as givens and prescribe the best methods..... Prescriptive principles and theories are goal oriented, whereas descriptive ones are goal free." (Reigeluth, 1983, p. 22). as the variable of interest.

Chapter 2 looks at Gagné's prescriptive theory of instruction (Gagné 1977; Gagné et al, 1981). This is then applied to three computer-based formats for the delivery of instructional material. With developments in the field of computer-based instruction, the second part of the chapter considers various learning models which are most applicable to multimedia displays and hypermedia such as the Mastery learning model (Carroll, 1963), the ARCS motivational model (Keller, 1987) and Wynn & Oliver's (1996) Interactive multimedia motivational model.

Chapter 2: Designing Instructional Environments

2.1 Instructional Design

Designing computer based learning environments is never easy. As well as designing content for learning, it is important to note what outcome of instruction is desired. Gagné (1977) outlines five categories of learning outcomes or "capabilities": (1) verbal information; (2) intellectual skills which comprise of five subordinate types including discrimination, concrete concept, defined concept, rule, and problem solving; (3) cognitive strategies; (4) motor skills; and (5) attitudes. He argues that all learning can be classified into one or another of these five varieties. While each of these categories are distinct from the others in the conditions of their learning, Gagné, Wager, and Rojas, (1981) consider only the first 3 outcomes, as they are most likely to be targeted by computer-based instruction.

2.1.1 Verbal information

Verbal information constitutes the memory of words, phrases or sentences. It involves the recollection of everyday names, labels, sentences and organised bodies of semantically related propositions, such as are found in connected discourse. Gagné (1977) calls this verbal information, not necessarily because it was stored in verbal form, but when cued for recall from memory, the student is able to 'state' it. Verbal memory is organised in the brain and is retrieved in some structured manner. The retrieval of information is facilitated when the student is supplied with external cues (Gagné & Briggs, 1979). These cues may be the use of mnemonic devices or mediational strategies. An example of a mnemonic device may be the use of a sentence to remember the order of the planets, with the first letter of every word referring to the name of a planet. Similarly, mediation can be used to aid the acquisition and recall of information. This involves creating meaningful links to previously learned material. An example of an effective mediator is the use of imagery, and is commonly used as a technique when teaching young learners. Briggs & Wager (1981) in a further classification of learning outcomes, discriminate between verbatim learning (the learning of names & labels), non-verbatim learning (such as facts), and substance learning (e.g. organised information).

2.1.2 Intellectual skills

While the learning of verbal information refers to acquiring declarative information or 'knowledge that', intellectual skills refer to the ability of 'knowing how' or procedural knowledge. Often the mind needs to use some symbolic operations in order to understand new information. The learned capability to manipulate such symbols constitutes an intellectual skill. Procedural knowledge is often associated with very efficient, automatic behaviours (Harvey & Anderson, in press). Intellectual skills include *discrimination*, *concrete concept* and *defined concept.*

Discrimination. This refers to the ability to differentiate different parts of the environment, such as colours, shapes and sizes. As we get older and gain experience, this learned ability becomes progressively more refined and complex. Gagné (1977) suggests an environment in which the conditions of learning are facilitated. The selective reinforcement of student responses helps learning how to discriminate between different types of stimuli. With the increase in trials, a selective positive reinforcement of correct responses (with no reinforcement of incorrect answers) gives rise to extinction of incorrect discriminations. Also, giving examples as well as non-examples helps foster discriminatory skills.

Concrete concept. The learning of some concepts is concrete in that they are directly observable. These include concepts such as spatial relationships (e.g., underneath), object properties (e.g., a 'square' box) and spatial directions (e.g., turning). These concepts can be identified by a description or by simply pointing them out.

Defined concept. A defined concept is a rule that classifies objects or events. The word 'nephew' is an example of this type of concept. Merely pointing at the individual would not be sufficient to understand the meaning of the word. Therefore, a definition of the concept is required for full comprehension. A person who has acquired a defined concept has learned the rules that govern it and is able to apply it to any instance of the class.

Rule. The learner acquires a rule when he or she can respond to a class of stimulus situations with a class of performances. In other words, the learner can show what is meant by the rule when one or more new instances are encountered. The rule is a relation, referring to two or more concepts (e.g., a rule of algebra, such as commutativity (a*b=b*a)). The learning of rules is reinforced when it is used in a variety of examples. Furthermore, rules which have been learned in one context can be directly transferred in another similar context (Singley & Anderson, 1989).

Problem Solving. Higher order rule learning (or problem solving) involves the combination of subordinate rules in order to solve a problem. In addition, the learner must be able to decide which rules are most appropriate for working out the solution. This involves the use of various strategies and the appropriate use of available resources. For example, when programming, the provision of constructs such as 'loops', 'if statements' and 'recursion', aid the user to solve the problem of writing a computer program. However, such assistance can also be limiting in that it confines the individual's creativity to what the system is capable of performing. Therefore, the problem to be solved is not only the conceptual design of what the program should do, but also the problem of using the tools available during the programming phase.

2.1.3 Cognitive strategies

Cognitive strategies form a significant part of problem solving. They represent the ability to control and manage other processes of attending, learning, remembering, and thinking. They form an aspect of learning such as 'learning to learn', an important modus operandi in acquiring and sustaining new information (Shulman & Keislar, 1966).

2.2 Gagné's Events of Instruction

Once these learning outcomes have been classified for the computer-based task, the next issue is to identify the means with which to 'teach' the material. In 'teaching', the material is presented via displays with some changing features that aid the acquisition of the material being learned. The displays support or enhance the learning of the material by means of numerous steps called *events of instruction* (Gagné et al., 1981). Each event functions to provide the external conditions for learning to occur.

Table 2.1 describes the relationship between events of instruction to internal learning processes (Gagné et al., 1981). Gagné and his colleagues argue that in any complete act of learning, there must be nine events of instruction, as shown in the right hand column. These events should satisfy or provide the necessary conditions for learning and serve as the basis for designing instruction and selecting appropriate media (Gagné, Briggs & Wager, 1992). The effective design of a computer assisted learning package may depend on varying the emphasis of each of the nine events of instruction. For example, if a child has little experience of computers in general, the first event of gaining attention may be less important as the child is already alert. However, the teacher may need to ensure that the child is watching the screen and not just the keyboard (Gagné, Wager & Rojas, 1981). The second event may also depend on the child's prior experience in understanding the lesson objectives.

Table 2.1

Internal Processes of learning and the External Instructional Events Which May Be Used to Support Them. Reproduced from Gagné et al. (1981)

Internal learning Process	External Instructional event
Alertness	1. Gaining Attention
Expectancy	2. Informing learner of lesson objectives
Retrieval to working memory	3. Stimulating recall of prior learning
Selective perception	4. Presenting stimuli with distinctive features
Semantic encoding	5. Guiding learning
Retrieval and responding	6. Eliciting performance
Reinforcement	7. Providing informative feedback
Cueing retrieval	8. Assessing performance
Generalising	9. Enhancing retention and learning transfer

Designing computer based learning environments is often driven by theoretical assumptions about how the learning process occurs and is best enhanced. Behaviourists (Skinner, 1938, 1953; Ferster & Skinner, 1957) stress repeated stimulus-response environments with contingent rewards as a means of promoting learning. Constructivists (Papert, 1980; Bruner, 1966), postulate that learning should be an active process with the learner and the environment. With the popularity of constructivist thinking, a shift has occurred in the design of new environments for instruction from the behaviourist "drill and practice" software, to more loosely defined and open ended software to facilitate exploration and discovery such as the programming language LOGO (Papert, 1980). Such open ended software is considered to be more constructional than instructional, with emergent rather than fixed goals. For teaching specific courseware to students certain programs are used repeatedly and three of the most common formats are outlined below.

Gagné, Wager, and Rojas (1981) outline three different types of computer-based instruction (CAI): *drill and practice*, *simulations* and *tutorials.* In *drill and practice* environments, the emphasis is on instructional events 6 & 7, where the program elicits a response from the learner and provides informative feedback (see Table 2.1). This format of questioning, answering and correction facilitates practice and improvement of existing knowledge. This allows students to practice or study information with which they are familiar but not proficient. Gagné (1989/82) outlines the benefits of drill and practice to achieve a level of 'automaticity' with basic knowledge. The benefit of drill and practice software is the practice of existing cognitive skills. Such skills are thought to be a collection of automatic processes and procedures (Simon & Chase, 1973). Automatic processing is fast, effortless, autonomous, stereotypic and unavailable to conscious awareness. Gagné (1982) believes that only through 'automaticizing' basic knowledge can students have the scope and ability to accept further information.

Simulations. Like a drill and practice, simulations contain instructional events such as eliciting performance and providing feedback (Gagné et al, 1981). They also include the presentation of an objective and present stimuli in the form of a description of the status of the current system. Simulations provide an environment for learning both course material and the practice of problem solving skills. The simulation allows students to try different approaches to solving problems with no fear of repercussions outside the simulation for failures. The simulation allows for learner control, an important component for effective instructional software (Kinzie, 1990). Within simulations there is provision for the learner to actively participate, rather than receiving the information in a passive way (e.g., television, lectures). The learner has control and is free to explore embedded concepts and relationships. This is done by manipulating various parameters of the system and studying the result as a change in the simulation environment (Beishuizen, 1992).

Computer based tutorials. "In this form of instruction, the learner is presented with an instructional sequence, consisting of text presentations, questions, and feedback" Gagné et al (1981, p. 20). This may be a linear sequence or branched, although the linear sequence is most common (Gagné et al, 1981). The tutorial process generally involves three events of instruction, presenting stimuli to be learned, eliciting responses to questions on the subject, and providing informative feedback. This three-step process is often repeated to form a single lesson (see Figure 1). Gagné et al. (1981) propose that the tutorial format can be expanded to include more events of instruction (see Figure 2).

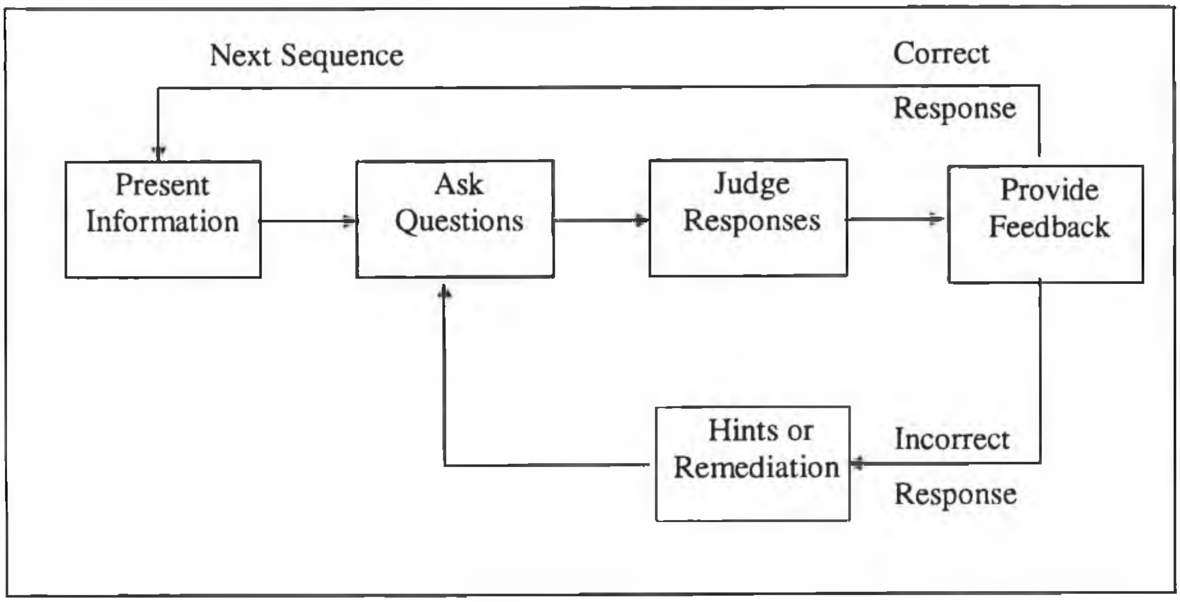


Figure 2.1. Typical procedure for tutorial programs: Reproduced from Gagné et al. (1981, p. 20).

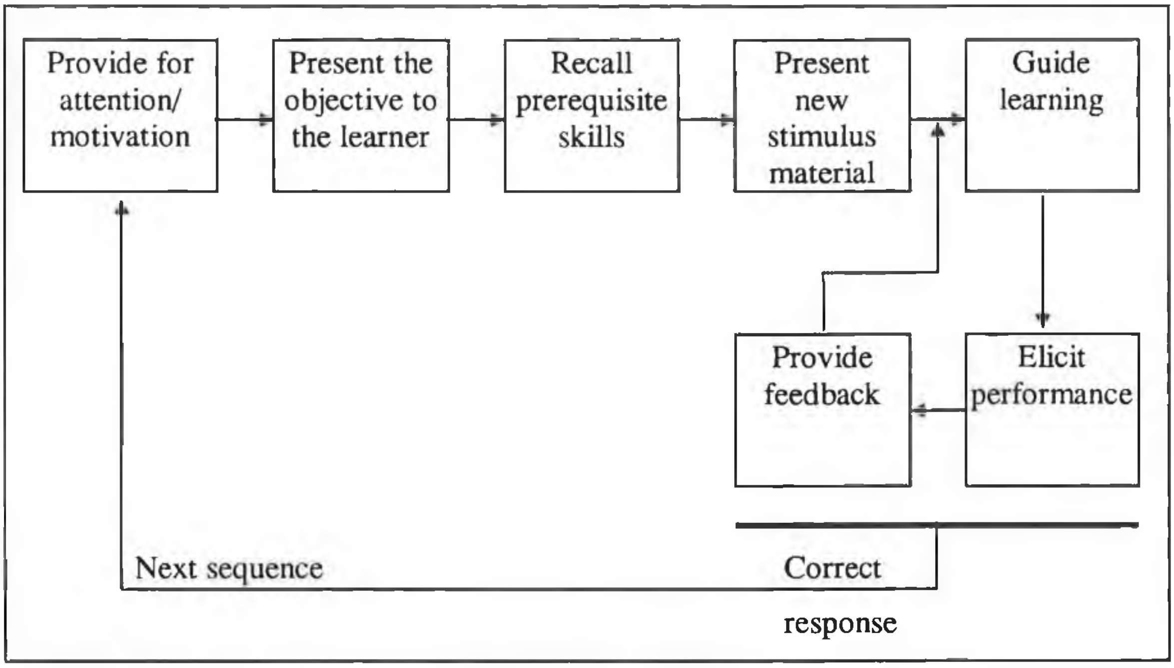


Figure 2.2 Procedure incorporating additional events of instruction. Reproduced from Gagné et al. (1981, p. 20).

2.3 Multimedia and Hypermedia

The emergence of multimedia-based applications and the advent of powerful authoring tools such as Authorware, has rendered the design of multimedia-based environments accessible to all. Multimedia, by definition refers to multi (meaning many) mediums for the representation of information. The idea of multimedia instruction is not a new one. For years various forms of media have been used in schools to teach students (e.g., books, videos, audio-tapes etc.). The use of different forms of media helps students remember learned material by providing more sensorial cues for recall. This also allows for more connections to be formed in the brain during the learning phase. With the advancement in technology, the term multimedia has now become associated with computer software encompassing text, graphics, animation, video and audio. The term is often wrongly used interchangeably with 'hypermedia', a concept which refers to applications for consulting multimedia information sources. As Mayes (1994, p. 3) points out "Multimedia systems are not primarily defined by their data structures, but by the nature of their communication".

With multimedia presentations, navigation through screen displays is often facilitated by clicking on sections of the screen. Hypermedia involves the clicking on relevant areas (hyperlinks) in texts, pictures; video, animation and audio which are linked to other displays. Hypertext refers to linking pieces of text only. Hypermedia implicitly advocates how to access information elements and how to criss-cross in information space (Kommers, 1996). Browsing and navigation are two main constituents of hypermedia, providing for maximum learner control. Hypertext or hypermedia systems have three main characteristics: (1) a database of information (called nodes or frames): (2) machine supported links between these nodes that allow for rapid movement through the information: and (3) a consistent user interface for interacting with the hypertext /hypermedia (Conklin, 1987). Users can find more information by exploring the environment and by following links that can elaborate on selected topics. The goal of hypermedia is to assist students in exploring relations, through providing a rich array of information (Duffy and Knuth, 1990).

There are various pedagogic underpinnings associated with hypermedia. The exploration of information is learner directed, with the ability to follow links to other pieces of information of interest to the student. Introducing hypermedia into the classroom can be difficult, as many children are not capable of using the system properly. It seems that there are two prerequisites to the introduction of a hypermedia system into a classroom. Firstly, when preparing a hypermedia session, the teacher should understand what links the students are likely to follow and thus guide the students' learning. Furthermore, students should be trained in how to use the hypermedia as a cognitive learning tool. This enhances *cognitive flexibility* and *metacognition* (Kommers, 1996). *Cognitive flexibility* refers to learning in complex and ill-structured domains and is defined as " the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands. This is a function of both the way knowledge is represented (e.g., along multiple rather single conceptual dimensions) and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval)" (Spiro & Jehng, 1990, p. 165). *Metacognition* is knowing what you know and knowing how you learn.

Interactive multimedia (IMM) combines the multiple forms of information through visual and auditory formats with the interactivity found in most computer games. Most modern computer based tasks have a multimedia content, but the computer–user interaction can be made more novel for the user with IMM. It focuses more on the affective domain, encouraging learning through 'edutainment' with appealing graphics, pictures, and sound. Although most edutainment software promotes sensory curiosity rather than cognitive curiosity (Malone, 1981), it is nevertheless, a highly engaging and motivating method of learning.

Mayes (1994) suggests some guidelines for the design of multimedia interfaces. The form of the presentation should be determined by the nature of the 'mental model' the user possesses. If it is natural for the learner to use 'visualisation' in order to process information, then the data should be presented graphically; if it is processed verbally, so too should the presentation present auditory information, but followed by an interval for transferring to memory. Mayes advises that mental processes (visuo-spatial and verbal) such not be performed concurrently in order to minimise negative interference. In the event of information overload, a change in modality is likely to recapture the attention of the learner.

2.4 Models of Effective Instruction

2.4.1 Mastery Learning

The provision of a multimedia environment allows for various methodologies for children's learning. One such model is Mastery learning. Mastery learning suggests that the focus of instruction should not be the time required for different students to learn the same material and to focus on different levels of ability (Carroll, 1963). In a mastery learning environment the main idea is providing enough time for all students to acquire the same level of understanding. This is accomplished by:

(1) A clear specification of what is to be learned and how it will be evaluated.
(2) Allowing students to pace their own learning.
(3) Assessing student progress and providing appropriate feedback or remediation.
(4) Testing that a final learning criterion has been achieved.

Bloom (1976) proposed four main hypotheses for a mastery learning model of instruction: Firstly a normal person can learn anything that teachers can teach. Secondly, individual learning needs vary greatly. Thirdly, under favourable learning conditions, the effects of individual differences approach vanishing point, while under unfavourable learning conditions, the effects of individual differences is greatly exaggerated. Finally, uncorrected learning errors are responsible for most learning difficulties. A mastery learning environment provides for self-regulated learning, increasing learner control.

2.4.2 The ARCS Model

The ARCS model (Keller, 1984) was developed as a method for improving the motivational appeal of instructional materials. It defines four main conditions (Attention, Relevance, Confidence, and Satisfaction) that have to be achieved in order for people to become and remain motivated throughout the learning session.

2.4.2.1 Attention

Attention should not only be gained early, but sustained throughout the lesson. This can be done through varying the sensory and cognitive curiosity of the given task. Keller (1987) gives some strategies for promoting and sustaining attention under the following six headings:

(i) Conflict: Provide information to contradict the user's past experience.

(ii) Concreteness: Give examples of every instructionally important concept or principle.

(iii) Variability: Vary the medium of instruction.

(iv) Humour: Use plays on words during redundant information presentation)

(v) Inquiry Build on problem solving activities at regular intervals.

(vi) Participation: Use games, role-plays, or simulations that require learner participation.

2.4.2.2 Relevance

Relevance refers to the relation to the subjects lives. Strategies to promote relevance include:

(a) Experience: Use analogies.

(b) Present worth: State intrinsic value of material being learned.

(c) Future usefulness

(d) Need matching: Satisfy needs for achievement, affiliation, establish trust and provide no-risk co-operative interaction.

(e) Modelling: Model enthusiasm for the subject taught.

(f) Choice: Provide meaningful alternative methods for accomplishing a goal.

2.4.2.3 Confidence

The confidence level of the user is important in ascertaining the appropriate approach to instruction. Many individuals with high confidence levels would attribute success internally (e.g. to their own performance), whereas people with low levels of confidence tend to attribute a good result to something external, (e.g luck) (Weiner, 1979; Gredler, 1992). Fear of failure is also an important consideration as there are many students who become disheartened when they fail at a task. Consequently the design of instruction should aim to improve confidence throughout the session. Strategies for promoting confidence include:

(1) Learning requirements: Give clear goals.
(2) Difficulty: Structure learning as increasing levels of difficulty.
(3) Expectations: Help students set realistic goals.
(4) Attributions: Attribute student success to effort; when it's true.
(5) Self-confidence: Allow students to become increasingly independent in learning and practicing a skill.

2.4.2.4 Satisfaction

The 'feel good' factor is essential to the design of any learning environment. The student should feel pleased with their work and receive the appropriate feedback for their efforts. Keller (1987) outlines some strategies for adding to the satisfaction felt by students. These include:

(1) Natural consequences: Allow student to use a newly acquired skill as soon as possible.
(2) Unexpected rewards
(3) Positive outcomes: Give praise for successful progress.
(4) Negative influences: Avoid threats.
(5) Scheduling: Vary the schedule of reinforcements in terms of both interval and quantity.

2.4.3 IMM and Motivation

This model of instruction focuses on ensuring the motivation of the user (Wynn & Oliver, 1996). Wynn & Oliver consider the affective domain in IMM instruction, an aspect of most computer based instruction which is often overlooked. Eight learner effects are defined for building motivating and engaging IMM. These include immersion, reflection, transfer, collaboration, learner control, curiosity, fantasy, and challenge.

2.4.3.1 Immersion

Immersion refers to both physical and psychological engagement in a computer task. The engagement is seen to be more than just in the cognitive domain and is primarily an emotional response to activities (Laurel, 1991). The concept of a microworld for instruction illustrates how this immersion may be facilitated. A microworld is a limited portion of the real world whose characteristics can be easily understood (Papert, 1980). The instruction is based in an environment in which the learner can explore, make choices and receive feedback for inputs during the session. Some educational attributes include: situated cognition, anchored instruction, androgynous environments, theme-based activities and simulations (Wynn & Oliver, 1996). Csikszentemihalyi (1990) in his Flow Theory of optimal experience describes how adults reach a state of happiness and satisfaction when occupied in some activity. They become so engaged (or immersed) that they appear to be carried with the 'flow' of the procedure. He defines flow as "the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it" (p.4). For example, a competent programmer could spend hours learning and using a difficult programming language and enjoy doing so. Certain conditions apply for a person to experience flow. They must be able to focus attention. Csikszentemihalyi (1990) calls it "psychic energy" because it acts as the "fuel" for the rest of consciousness. "Psychic entropy", in contrast happens when some distraction enters consciousness and diverts our attention. Experiencing flow is also dependent on providing an optimal challenge to match the individual's ability during the activity. This is analogous to Malone's (1980) theory of 'Toys' vs. 'Tools'. The activity or computer programming language is no longer seen as a tool but rather as a toy with which to play with and master.

2.4.3.2 Reflection

While engaged in the activity on the screen, the learner is reflecting on the material being taught. The more time engaged in the task, the more likely the learner will assimilate the information displayed onscreen. Reflection is therefore a time-based phenomenon. A well accepted view held in learning theory is that time on task is highly correlated with motivation and some achievement. Reflection involves such components as higher order thinking, problem solving skills, exploratory and experiential learning (Resnick, 1987, cited in Wynn & Oliver , 1996). Reflection can be facilitated within IMM by answering questions, solving problems, locating new areas of interest onscreen etc.

2.4.3.3 Transfer

The purpose of any instructional environment is to aid the transfer of learned skills to their uses in the real world. Ensuring the close representation of a real world phenomenon (as in situated learning and anchored instruction) can facilitate transfer. Wynn & Oliver (1996) suggest theme-based, real world activities presented in various scenarios with some problem solving to accomplish this objective. Transfer is enhanced by supplying a variety of contextual cues besides the essential stimuli for learning. Providing multiple examples when demonstrating learned rules can enhance intellectual skills. Varying content of problems facilitates retention and transfer of cognitive strategies, and motor skills can be practiced in various environments with some distractions (such as noise) to aid in their transfer to real life (Gagné, 1977).

2.4.3.4 Collaboration

While computers have often been seen as isolated environments, they have a large social component, especially when considering computer games. The collaboration can be between two students, a teacher and a student, or a student and the computer. Where facilities are insufficient to allow one user per computer, collaborative use of the computers is often a necessary. This necessitates the use of educational packages for some computer-based collaborative learning. Although there is opposition to student-student collaboration (Laurillard, 1993), there seems to be much support in the literature on group-based instruction. According to Johnson and Johnson (1986), there is evidence that co-operative teams achieve higher levels of thought and retain information longer than students who work quietly as individuals. The shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers (Totten, Sills, Digby, & Russ, 1991). Johnson, Johnson and Stanne (1985) maximised learning by making group members collectively responsible for the product they developed.

2.4.3.4 Feedback

As part of the collaboration between the student and the computer, feedback is an important feature in any model of instruction. It gives the learner a sense of how he or she are performing and is needed as a source of continuing motivation (Laurilard, 1993). Informative feedback should give:

(1) Information to what answers were right and those that were wrong.
(2) Information about the learners output (e.g., the change in state of a simulation from a manipulation of some of the parameters of the system).
(3) (a) A diagnosis of which part of the output was wrong and
    (b) what was right.
(4) An explanation of why the right answer was right.
(5) An explanation of why the student's wrong answer was wrong (Draper, 1997).

Sources of feedback include the computer, other students, the teacher and the students themselves. Each source will have a different effect on the child's learning. Feedback can occur in any sensory modality, but for simplicity, there are two main categories in CAI: Visual and Auditory. Visual feedback can be in the form of spatial representations on the screen, such as pictures, graphs etc. Verbal feedback is non spatial and refers to text (words and numbers) or audio presented by the computer (Rieber et al., 1996). Rieber et al (1996) tested subjects' explicit and tacit[2] knowledge of the contents of a discovery-based learning environment on Newtonian physics. He and his colleagues found that graphical feedback was superior to textual feedback for helping subjects complete the gaming activity. They also found that subjects needed less interaction with the computer when graphical feedback was given, suggesting that it is easier than textual feedback to extract the relevant information. However, it would seem to depend on the quality of the graphical feedback in any computer-based task.

The depth of feedback may need to be altered as to fit the learner and teacher's needs. Often children of primary school age prefer to receive praise from teachers as a source of feedback rather than a lengthy examination of their work. This form of 'shallow' feedback suits both the pupil and the teacher as it does not consume too much time or interfere with the exercise. Elements within the computer program (e.g., a small firework display) can provide the contingent feedback needed to maintain interest.

2.4.3.6 Learner Control

An important criterion in the design of CAI is how much control to give to the learner over its environment. Learner control refers to the ability of the learner to choose his or her own paths, content, pace and nature of the feedback they receive (Reeves, 1990; cited in Wynn & Oliver, 1996). Kinzie (1990) outlines three main issues in interactive learning: learner control, self-regulation and ongoing motivation to learn. Research in learner control has revealed that giving too much control over the environment does not improve learning as learners do not maximise the potential of the system, suggesting that guided learning is superior (Hannafin, 1992). Giving students the control of contextual factors (such as the story they want to read) leads to more positive attitudes towards the task. However, not all students are motivated by providing them with control over their learning (Reeves, 1990). A balance between learner and system control is needed to enhance learning and maintain intrinsic motivation (Wynn & Oliver,

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[2] Implicit or tacit knowledge refers to knowledge which is generally unknown to us and which usually remains unanalyzed by the learner (Alexander et al., 1991).

1996). Wynn & Oliver suggest that the microworld can be programmed to adjust the level of control as per the student's level of competence. Such control would range from linear or system control, through guided discovery to a browsing mode.

Ross and Morrison (1988) in their previous studies found that students, especially low achievers, lack the relevant knowledge and motivation to make correct decisions about the pacing, sequencing of content, use of learning aids, and amount of practice needed for learning. They suggest eight situations in which learner control is likely to be beneficial:

- Learners are older and more mature.
- Learners are more capable.
- Higher-order skills are taught rather than factual information.
- The learning content is more familiar.
- The learner is provided with advice to make decisions and use strategies known to be effective.
- Learner control is used consistently within a lesson.
- The unsuccessful learners are immediately provided with system control.
- If learner controlled sessions are evaluated and corrected afterward so that misconception and omissions can be remediated.

2.4.3.7 Fantasy

According to Malone (1981, p. 360), "fantasies can make instructional environments more interesting and more educational". They are induced when the student is immersed in the environment, believing that they are really involved, and are induced when performing mental operations during a computer task. Rieber (1996) states that fantasies can be considered as either endogenous or exogenous to a game's content. An example of an exogenous fantasy would be the game "Hangman", where any content can be superimposed on top of this fantasy. The game is therefore independent of the content. Exogenous fantasies can be thought of as the educational "sugar coating" or the "bells and whistles" to promote interest in the learner. In contrast endogenous fantasies weave the content into the game. Consequently, if the learner is interested in the fantasy, he or she will be interested in the content.

2.4.3.8 Challenge

Challenge is incorporated into any IMM task by providing goals that are difficult, but not impossible. There should be multiple level goals with variable difficulty, hidden information, randomness, and arbitrary stimuli to consider what is of value and what is not (Malone, 1980; Wynn & Oliver 1996). Wynn & Oliver also suggest that IMM offers an ideal opportunity for viewing an expert performance of a skill (e.g. through video, animations etc.), a concept often used in computer-game design.

2.5 Lessons learned from computer games

With the increasing complexity and processing power of computers it has become easier to design more complicated environments for self-regulated learning. Jones (1997) in a survey of computer game aesthetics found "neatness" to be very important part of playing a particular product. He suggests some ideas on how to improve computer-based learning using lessons taken from computer games.

In summary, Jones (1997, p. 3) found that quality of the multimedia components promotes a richer environment, with "ultimately more meaning and enjoyable experiences". They must however, have a purpose to them. Jones refers to this effect as "pushing the envelope" i.e. promoting the technically impressive elements, while having no real relation to the environment created. A second point is that the design of learning environments should contain elements of "fast action" to provide immediate feedback, as well as a more unifying problem to be solved (e.g., mini games in a larger strategy game). Thirdly, some information should not be made obvious to the learner, forcing them to "think around corners" (the use of various problem-solving skills when required to figure a solution to a problem). This promotes dissonance (and reflection) and is more often seen in computer games, as they are not constrained by content. Fourthly, failure is often seen in games and mistakes need to be rectified in order to proceed. Jones believes that this creates deeper connections with the content than merely trying to remember answers. Fifthly, the virtual world should contain engaging elements such as “believable characters and circumstances, an illusion of reality, and a set of controls that make sense relative to the reality that they are engaged in”. Finally, an engaging environment could provide predetermined problems for learners to solve (Jones, 1997, p. 3-5).

As with any new toy, young children do not have any fears when using a computer and will often play and explore the environment just to see what it does. The design of any multimedia learning system for children needs to reflect this and include elements that will make the experience both an enjoyable and informative one. The provision of a fantasy world is more appealing to young children because their minds have not yet been constrained through exposure to cultural and scientific conventions. Constructivists (Papert, 1980) believe that computers should be used by children to actively create and learn at the same time. LOGO is a good example of such a learning environment. Behaviourists (Skinner, 1953) see the computer-based learning system as a means of reinforcing certain behaviours (through interaction with the computer and the user) and facilitating autonomous learning through multiple reinforcements. Chapter 3 looks at these cognitive and behaviourist influences in the design of computer games.

Chapter 3: Core Elements of Games

3.1 Introduction

In Chapters 1 and 2 various learning processes and the design of computer based instructional environments were discussed. It was also noted that a number of theories about instruction have been developed from studies with computer games (e.g., Malone, 1981; Jones, 1997; Wynn & Oliver, 1996). In this chapter elements of games which make students or game-players continue to enjoy and persist in playing are outlined. For the purpose of ascertaining the educational application of games, a taxonomy of games is developed. The educational effectiveness of games as instructional environments is discussed.

3.1.1 What's in a Game?

"A game is a closed, formal system that subjectively represents a subset of reality" (Crawford, 1984, p. 4). By closed, we mean that the game is complete and intact in its structure. The alternative world created inside the game has no need for reference to the outside world. Therefore, it is self sufficient. 'Formal' means that the game follows a well-defined set of rules. In some cases, the games may have less formal rules but this is not as common. It is a system, because various parts of the computer program interact with each other, often in complex ways. It is a representation of reality, albeit a subjective one. The game consists of characters, places, and things to do. Therefore, an element of fantasy comes into the mind of the game-programmer and is hence, passed on to the game-player. This representation of a fantasy world, created via the computer, facilitates this subjective representation of real world phenomena. Computer games vary in the interaction between player and game. Some games, such as PONG (Atari,1972) provide little interaction whereas others such as FIFA SOCCER '97 (Electronic Arts, 1996) allow a far richer interaction.

Challenge and *Conflict* occurs naturally from the interaction within a game (Malone, 1981, Crawford, 1984). The game focuses on the active participation of the user to attain a certain goal. To achieve this goal however, a number of obstacles have to be overcome. If these obstacles are active or dynamic, if they purposefully respond to the player, the challenge becomes a game (Crawford, 1984). Usually these obstacles involve an intelligent agent. If this agent actively blocks the progress of the player, a conflict arises. Hence, conflict is an integral part of computer gaming. The agents of conflict may be another player, the computer simulated player, or the resolution of a problem on-screen. Conflict is most commonly associated with violence in the real world. It is therefore, not surprising that a large number of games use a violent theme for the conflict element.

3.1.2 Reinforcement in Games

For computer games, a number of elements act as reinforcers for continuous game playing, facilitating multiple reinforcements. Examples include achieving the next stage in the game, defeating the other opponent or increasing the score. By manipulating the difficulty of achieving these rewards, the game entices the player to test his or her skill. If the difficulty of the game is too great for the player, he or she will stop playing. If it is too easy he or she will get bored and stop playing also. Consequently, there must be some initial high variable schedule of reinforcement with a gradual reduction to a low variable partial reinforcement schedule for optimal continuous gameplay.

This is easily seen in games such as SPACE INVADERS (Atari, 1980). The number of aliens to eliminate is small in the beginning and gradually increases the further the player reaches in the game. The number of times they shoot at the player's character (spaceship) also increases, as does the rate at which the group of aliens move down the screen, towards the spaceship at the bottom. Periodically during the game, an alien spaceship appears, travelling across the top of the screen. This acts as a bonus alien, whereby, a large number of points will be given to the player if it is eliminated. The bonus alien can be seen as a variable interval reinforcement with an increase in score being the reinforcer. It is noteworthy to see that the reinforcement (increase in score) is contingent to the behaviour (eliminating the alien). Thus, optimal operant conditioning is facilitated (Skinner, 1953).

3.2 Persistence

Loftus & Loftus (1983) in addition to reinforcement, identify concepts such as cognitive dissonance and regret, to illustrate what makes games so compelling.

3.2.1 Cognitive Dissonance

Cognitive dissonance theory assumes that when a person acts or holds beliefs that are in conflict with each other, the person will act so as to reduce the conflict (Festinger & Carlsmith, 1959). In their experiment, Festinger and his colleague saw that people will often alter their attitudes about a task if they are asked to lie about it. In their experiment, subjects were paid a various amounts of money to lie about a boring task. It was found that it was harder for the low pay group to maintain the view that the task was boring and consequently rated the task less boring than those who received a large amount of money to lie. Therefore, the perception of the low pay group had to change in order to justify the lies that they told. The better paid group were "hired to lie" and therefore would seem less likely to change their view that the task was a boring one. Loftus & Loftus (1985) describe this effect in terms of intrinsic and extrinsic motivation. If the subject receives a large some of money (an extrinsic reward), it makes the act of lying easier to deal with. If the extrinsic reward was reduced, the intrinsic motivation had to be generated, hence, subjects were found to rate the task as more intrinsically fulfilling. This is in agreement with Malone's (1980) suggestion that intrinsic fantasies are more motivating to the student. In a study of children performing tasks in which they receive continuous extrinsic rewards, a loss of intrinsic motivation was found (Lepper et al., 1973). Therefore, the oversupply of extrinsic reinforcement undermines the intrinsic motivation inherent in doing the task.

3.2.2 Regret

If a person was to lose to an opponent in a chess match, he or she would often consider the reason why he or she lost. If their play early in the match (poor naive play) affected the outcome i.e. their losing the match, the regret would be less than if they had lost because of a careless mistake toward the end of the game. Kahneman & Tversky (1982) explain this phenomenon in terms of the creation of alternative worlds. We create alternative worlds to better understand our failures and account for them. According to Kahneman & Tversky, when an unfortunate event occurs, an alternative world is constructed in the mind where unfortunate event does not occur. Therefore the closer to the real world the alternative world is, the more regret is felt by the person. To eliminate the feeling of regret, the person will play again. If the game has options such as 'Save game' and 'Continue', fixing the mistake made in the game before is much easier. The game can continue on from before the mistake was made. The 'Save game' and 'Continue' options facilitate an alternative world and entice the user to return to game-play.

3.3 Taxonomy of Games

There are thousands of computer games commercially available today. Computer gaming is not confined to children alone as many adults play computer games also. To better understand the interest and educational applications of games a taxonomy of the most popular games is proposed. This taxonomy is a revised version of a taxonomy developed by Crawford (1984). While Crawford devised an excellent taxonomy, many of the games have been superseded by more complex and stimulating games. The new taxonomy differs from Crawford's as it reflects new developments in the design and complexity of games on the market today. For example, the differences between adventure games and skill and action elements found in Crawford's taxonomy have become more intermixed with the newer action adventures.

Current computer games can be separated into two main categories: Skill-and-Action Games and Strategy Games. Each one has many subcategories. Skill-and-Action Games emphasise perceptual and motor skills, whereas Strategy Games emphasise more cognitive effort (Crawford, 1984). There may exist some overlap between the two categories (i.e., they are not mutually exclusive). Therefore, some games have characteristics of both types.

3.3.1 Skill-and-Action

This class of computer games appears to be the most popular, with most Arcade games being S&A Games. These games are characterised by real-time play, heavy emphasis on graphics and sound, and the use of joysticks (or joypads) rather than keyboard input. The primary skills needed for these types of games are eye-hand co-ordination and fast reaction times. Skill-and-Action Games can be grouped into five categories: Combat, Sports, Racing games, Platforms and Miscellaneous games. S&A Games require plenty of practice and procedural knowledge in order to progress in the game. These games have not been widely used in education, possibly because of their high emphasis on amusement rather than education. It is suggested however, that educational application of these games lies in their ability to engage and motivate the user (e.g., as possible extrinsic rewards for achievement; see Chapter 4). Moreover, they can be used to accurately simulate real phenomena, such as the complex movements in martial arts or other sports.

3.3.1.1 Combat Games

Since challenge is an inherent component of computer games, it is not surprising that a vast amount of commercial games have conflict as their central theme. Combat games are games that have a violent content, with the emphasis on destroying objects, characters, or other players. These games can be divided into two more categories. '*Shootem'ups*' and '*Beatem'ups*'. *Shootem'ups* involve destroying objects (or characters) on the screen with an arsenal of weaponry. A classic example of this type of game is

SPACE INVADERS (Atari, 1979). The user controls a spaceship with a laser cannon, located at the bottom of the screen. The aim of the game is to destroy the alien characters at the top of the screen before they get down to the bottom. There are many other types of *'shootem'ups'*. Some are based in three dimensions with some role playing. Examples of these games include DOOM, QUAKE, and DESCENT. These games involve the user assuming the role of a character and obliterating the other opponents in a virtual world. To succeed in these games, the game-player requires good mental imagery and mapping skills as most games scenarios are set in complex three dimensional worlds (e.g., buildings, streets, dungeons, sewers etc..). These games often have hidden information the user must find located within the environment. Certain cues are provided to the user to indicate hidden or secret rooms for example, a crack in the wall would indicate that the player can bow it up. Other *'shootem'ups'* include point and shoot games. In these games, the user points to or positions crosshairs in front of objects or characters to shoot. Some of these games use a gun as the input device such as a gun to point and shoot at the objects (or characters) onscreen.

'Beatem'ups' are games of close, hand-to-hand combat between characters. It usually involves hitting your opponent until he/she is knocked out (e.g., MORTAL KOMBAT). Beatem'ups are well known for the procedural knowledge required to beat the other opponent. This may involve remembering very complex combinations of moves within the game, as well as intricate gaming strategies. For example, in MORTAL KOMBAT each character has a plethora of possible combinations of moves and special actions that are different to all of the other characters. Each character is given strengths and weaknesses that the game-player must remember. In order to master such a game, the player must remember these moves and be able to use them when required during the game. This indicates complex rule following as well as explicit memory of available moves.

3.3.1.2 Sports

Sports games involve the simulation of actual sports. Games like tennis, football, basketball, snooker, pool, even sailing has been transformed by computer code into complex graphical interaction with the user and the computer. Sports games are quite popular currently with the newer games using three dimensional graphical designs (e.g., FIFA SOCCER '97; Electronic Arts, 1996). As research has shown, expert learning comes from practice and the use of some mental imagery skills (Moran, 1993). With the computer-based version of Snooker which has a large strategic composition, the computer simulated game can accurately mimic the spin and projection of the balls on the table. The use of a virtual environment to simulate the playing of the actual game helps transfer the learning onto real life play. Again rules that are learned from playing the game can be transferred to the similar real life context (Singley & Anderson, 1989). Furthermore with newer, more artificially-intelligent games, the opponents can match the player's skill and adapt to their strategies.

3.3.1.3 Racing Games

These games involve a straight forward race between players. The idea is to be in first position at the end of the race. The race directly challenges the players to engage in competition and forces them perform well in order to succeed. Therefore, an increase in self-esteem as a result of playing is common. There have been variations on this theme to include special *'power' ups'* to aid in the driver's quest to win the game (e.g., MARIO KART and WIPEOUT). *Power' ups* give the driver either increased speed or weaponry, to slow down other opponents. Randomness is facilitated in these games as the users progress is often blocked by the positioning of other randomly placed vehicles.

3.3.1.4 Platforms

Platforms are used to create an environment for the character to move around. The screen often scrolls both up/down and left/right in order to keep the character on the screen. Often the character has to avoid objects, destroy others, and reach a certain point in the area in order to finish the levels. A excellent example of this type of game is MARIO BROTHERS (Nintendo, 1980's). In this game, the player's character, Mario, breaks up blocks to reveal coins, *power-ups* or passages to secret levels. This search for hidden information helps the player maintain his or her curiosity and hence, the willingness to continue (Malone, 1981). This type of game has been used to facilitate an environment in which to move around and the educational content has been included to specific parts of the game (e.g., in Word games at Camelot on an encounter with a guard, the user must answer some mathematical problems; see Chapter 4 for a more detailed description of the game).

3.3.1.5 Flight Simulation Games

Traditionally, aircraft simulations have been designed to objectively model their real-life counterparts. However with the increase in the capability of computer graphics and speed, flight simulations have entered the games market. Flight Simulation games differ from traditional simulations in important ways. Traditional simulations are designed to objectively model the vehicle being simulated in a virtual scenario. Flight Simulation games are an enhanced version of a simulation to emphasise the gaming element. For example, AFTERBURNER is an artistically simplified model of a jet-fighter simulation. The game allows the user to see the front of the plane and gives control of the aircraft by means of a joystick. An arsenal of weaponry is given to the plane to shoot the other planes on the screen and levels are passed when a certain number of planes are destroyed. The traditional simulation would not have levels, and would merely involve the completion of a task (E.g., landing the aeroplane). These games have often been used by the military to increase reaction times of their pilots (Gopher et al, 1992).

3.3.1.6 Miscellaneous Games

There are many other types of games that are unique in their own way in the category of S&A. Such games include Paddle games, Maze games and Arcade games. In Paddle games (e.g., PONG, ARKANOID, KRYPTON '95), the paddle is used to hit a ball and send it around the screen destroying blocks and bouncing off walls. For KRYPTON '95, certain power'ups are given during the game to assist the player in completing the level. These include a laser cannon, increased size, extra balls and extra lives. Maze games (e.g., PAC-MAN) are based around a maze generated on the screen. The user has to navigate his character around the maze, avoiding other characters and collecting certain power'ups. Arcade games (e.g., ULTIMATE PINBALL) are transported versions of their Arcade counterparts on the computer screen. Some of these games have been adapted to include some complicated levels and bonuses, not possible on their arcade versions.

3.3.2 Strategy Games

Strategy games focus on the user's cognitive ability to progress in the game. There is less emphasis on boisterous play and more on the problem solving and declarative knowledge of the user. In this category there are Adventures, War games, Educational games, Simulation games, Management, and Miscellaneous games.

3.4.2.1 Adventures

Adventure games involve a large element of fantasy and often have Dungeons and Dragons[3] theme to them. They usually involve interaction with other characters, collecting items for use, searching for hidden objects, and exploration of a virtual world. The method by which the user does these actions can be represented by text instructions or by graphical design. Older games were mostly text based with some keywords (such as: jump, pick-up, go, get, carry, shoot, and so on) to perform tasks inside the game. Text-based adventure games have largely been replaced with actual manipulation of the character on the screen to perform actions. The main character (the user's character) often has to solve complex puzzles in order to progress to a next stage. These puzzles may directly challenge the user's cognitive skill, or, their procedural knowledge of a complex series of movements. An element of Skill and Action is therefore, included in most of the

[3] Dungeons and Dragon's fantasy role playing. Created by Gary Gygax, D & D games were initially non-computer games of exploration, cooperation, and conflict, but needed a minimum number of players to play the game. However, this idea have been transformed with the use of computer generated characters, to facilitate one player gaming (Crawford, 1984).

newer games. Adventures usually involve exploration and discovery learning, as not all relevant information is given to the player at the beginning of the game.

3.4.2.2 War Games

These games involve the strategic manipulation of armies and attack scenarios in order to beat another opponent. Therefore, the formulation of complex strategies is necessary to succeed. Non-computer War games have been around for centuries with many battle plans being either drawn or demonstrated, with the use of representational objects. In the computer games, the game scenarios and characters are computer generated. Examples of this type of games include: EASTERN FRONT 1941 (Crawford, 1980's) and COMMAND AND CONQUER. Both involve a lengthy period of gameplay that is characteristic of this type of game. Certain board games such as chess, have also been converted into a computer to facilitate one player gaming.

3.4.2.3 Educational Games

Dempsey et al. (1993) define Instructional (or Educational) gaming as any overt instructional or learning format that involves competition and is rule guided. The competition does not have to involve more than one player, since the player can compete with him/her self (using some scoring system) or against the computer generated opponents. Therefore many computer based tasks in an educational environment can be considered as educational games. For example, a drill and practice program can be considered a game if a score is given at the end and registered on a high-score table or with the user's previous results. Dempsey et al (1993) in their review of instructional gaming over the previous decade, separated games into simulations, puzzles, adventures, experimental games, motivational games, modelling and others, for example, frame games. Non-computer frame games have often been used in business to facilitate group cohesion and knowledge of group processes (e.g., Growing a Team, Vertrees, 1997). Dempsey et al (1993) found that simulation games were the most common type of education game found in the literature. Card games are also found in this category due to the determination of probabilities and risk. Nevertheless there is much debate as to whether these games should promote the gambling aspect of their real-life use (Dempsey et al, 1997).

3.4.2.4 Simulation Games

The term 'simulation' refers to an objective computer representation of real-world phenomena. However, if a score is given during the simulation and is compared with successive attempts, then the simulation becomes a simulation game, as the element of competition is introduced. The mere completion of an event during a simulation does not make it a game (Dempsey et al, 1993). In an instructional context, these games can be used to change attitudes (e.g., GHETTO), improve knowledge of certain subjects (e.g., OREGON), improve interpersonal skills and group decision making (e.g., INS2) and learning cause and effect (e.g., THE INCREDIBLE MACHINE). Simulation games are the most common type of computer games used in education because of their long history and new advances in computer technology.

3.4.2.5 Management Games

These games focus on the managerial skills of the player. Games of this type generally involve complex logical and strategic thought. General themes involve the construction of cities, civilizations or even theme parks. The player often has to construct an environment and maintain it over a period of time. This involves managing both resources and people in often difficult scenarios. Gameplay is quite long in these games and usually takes a number of hours to finish a game. SIMCITY is an example of this type of game. These games have often been used in business to improve managerial skills and test levels of competency. These games are inherently educational as most of the computer environments or game scenarios are simulations of real-life situations.

3.4.2.6 Miscellaneous

There are many other games that do not seem to fit flawlessly into the other categories of Strategy games. Board game conversions (such as MONOPOLY) seem to be quite popular amongst computer game players. The computer can act as the opponent and its level of expertise can be altered to match the ability of the player. There exist some games which focus both on cognitive skills, and sensorimotor skills. Examples of these games include TETRIS and PUZZLE BOBBLE. TETRIS relies heavily on the mental rotation ability of the user to control falling shapes and place them amongst previously placed pieces at the bottom of the screen. PUZZLE BOBBLE involves the shooting of a coloured ball to the top of the screen where various other balls are positioned. When the ball hits two or more other balls of equal colour simultaneously, they disappear. The aim of the game is to make all of the balls disappear off the screen. This game also involves a high level of strategic thought as well as fast action by the game-player.

3.5 Incorporating gaming strategies into multimedia software design:

Computer games can serve many functions. They may used to entertain, tutor, practice skills, develop new skills, automatise, or even change attitudes. In their review of the literature, Dempsey and his colleagues (1993) outline some instructional benefits of games. These include improved practical reasoning skills, increased motivation, reduced training time and instructor overload. Gaming strategies have been employed in such areas as attention reduction training and complex problem solving.

3.5.1 Studies on Games

The research on the use and effectiveness of gaming in education is quite sparse (Dempsey et al (1997). A study of educational games and the effect of gender and learning styles, was conducted by Dempsey, Lucassen, Haynes & Casey (1997). In their study, 40 'educational' computer games from eight different categories such as

Adventures, Card games, simulations, Arcade, Board games, Puzzles, Word games and Miscellaneous games were played by 40 adults (20 male & 20 female). Various tests were administered to the subjects to ascertain their demographics (age, experience..etc.), their experiential styles (Kolb's Learning-Style Inventory; Kolb, 1984), game preferences, and their degree of optimism/pessimism (CAS-Q Inventory; Seligman, 1992). Two gaming scales were specifically developed for computer game use and administered after each game. Firstly, a Motivation Gaming Scale (a modification of Keller's Motivation scale; Keller, 1987) measured attention, relevance, confidence and satisfaction for computer gaming. Secondly, a Gaming Attribute Scale was derived from the literature review. "The areas analysed from this scale included: challenge, fantasy, curiosity (Malone, 1981); fidelity, artificiality, interactivity (Duchastel, 1991; Complexity (Jacobs & Dempsey, 1993); and control (Westrom & Shaban, 1992)." (Dempsey et al, 1997, p. 4).

In a comparison of the related items on Motivation Gaming Scale by Gaming Attribute Scale, results showed that:

- Card games and arcade games were more likely to be considered Eye-catching by the user.
- Puzzle and board games seemed to have a high level of enjoyment for the paradoxical nature of the game and less need for hidden information.
- Board games provided little variability enough to maintain attention.
- The least amount of control was found for simulations.
- The games which indicated the greatest level of satisfaction were Board, Word and Miscellaneous games with the Adventure and Card games having the lowest levels.

The results of the interviews with the subjects showed some suggestions to the use of computer games in an educational setting. These are shown in Table 3.1

Table 3.1. Suggested Uses of Computer Games in an Educational Setting. From Dempsey et al. (1997, p. 17)

Adventure Games

Survival Skills
Inventory
Supply & Demand
Probability
Consequences
Problem-solving
Navigating
History
Purchasing
Budgeting
High-order thinking skills
Learning verbs/nouns
Spelling/writing

Arcade Games

Hand-eye Coordination
Reflexive Action
Motor Skills
Speed Simulations
Multiple problems/priorities
Timing
Angles, trajectories
Air current
Planning
Decision making

Board Games

Budget
Logic Strategy
Counting
Planning
Problem-solving
Deductive Reasoning
Critical thinking
Coordination
Navigation

Card Games

Probabilities
Calculate Risk
Develop Strategies
Addition
Pattern Recognition

Miscellaneous Games

Logic
Pattern Recognition
Short-term Memory
Learning Alphabet
Probabilities
Pattern Matching
Audio/visual discrimination

Puzzles

Planning Strategies
Thinking Ahead
Spatial Orientation
Map reading
Architectural Design
Problem-solving
Hand-eye coordination
Pattern recognition
Matching
Assembly/disassembly

Simulations

Writing Fiction
Teaching Framing
Tactical & Strategic Planning
Co-ordinates
Velocity, speed, wind, angles
Decision Making
Consequences
Economics/Stock Projections

Word Games

Vocabulary
Spelling
Problem-solving
Remediation
Verbal Information
Drill & Practice
Reinforcement

The results showed that, in general, female subjects found the games less motivating, were less optimistic, and felt their success was due more to luck than skill in comparison to the male subjects. An analysis of Kolb's Learning Styles showed that females were largely accommodators and divergers, with the males being more assimilators and convergers. This was reflected in the gameplay with a larger percentage of females (and accommodators) being less competitive than the males (and assimilators). Experience with each type of game varied between the four quadrants. For example, accommodators were more experienced with word games while the majority of remaining learning styles were neutral in rating their experience.

With Dempsey et al's study, the subjects who participated in the experiments were between 18 and 51 years of age. Since these subjects were mature and frequent computer users, the effects found with the various learning styles may be different for younger age groups. Also, presenting such a detailed questionnaire would be impossible for young children to comprehend and answer. What is interesting though, is that the different learning styles showed varying levels of competitiveness. Assimilators were found to be most competitive, while Divergers were found to be least competitive. Less competitive Divergers tended to be female. With this in mind, the design of games (or elements such as competitiveness) could be tailored to the learning styles of the students.

In a review of educational effectiveness of games (both computer and non-computer), Randel et al (1992) found seven out of eight studies involving maths found that the use of games was superior to classroom instruction for improving math achievement. Five out of six studies demonstrated that games can teach language arts effectively, particularly when specific objectives are given to the student. Simulation/games show greater retention over time than conventional classroom instruction. In 12 out of 14 studies, students reported more interest in simulation and game activities than in more conventional classroom instruction.

3.5.2 Gaming Strategies

By far, the most common gaming strategy employed by the participants in Dempsey et al's (1997) study was found to be trial and error. They found subjects often used trial and error initially, and then looked for instructions and hints within the game. The strategies used depended on the type of game being played as each game played had its own unique elements. Examples of other strategies used include: retracing steps, being aware of surroundings, using prior knowledge, paying attention to consequences, reading aloud, using different phrases, random shooting, trying different routes, trying different selections based on feedback in the game, using options within the game (e.g., extra screens, speed of game), going on feelings rather than probabilities, trying to establish a pattern, taking notes ..etc. "Providing examples of how to play the game, winning prototypes, can facilitate engagement in a game as well as incidental learning" (Dempsey et al, 1997, p. 11).

From Dempsey et al's (1997) game strategy results, it is apparent that trial and error was the most common method for understanding how a game works. Learning how the game operates takes time and requires practice. Therefore simplicity in design and clear and concise instructions are important factors for including games as instructional tools. With exogenous games, the format is often both simple and familiar to the users. This reduces the "aversion factor" to learning in a new and complex environment. A common problem that is found in educational programs is the lack of presentation of objectives. This commonly leads to frustration and confusion to what the user is expected to do. Bialo & Erickson (1985) in an evaluation of 163 computer games, found that only one-third of all the programs had "well defined educationally appropriate objectives". The next section in this chapter describes two types of games used for instructional puposes.

3.6 Endogenous and Exogenous games

For the purposes of better understanding computer games pedagogic role in CAI it is necessary to define two inherent types of educational games. For this purpose it is suggested that they be referred to as Exogenous and Endogenous games. The word endogenous means growing or originating from within whereas the word exogenous is defined as growing or originating from outside (The Concise Oxford Dictionary, 1995). Malone (1981) distinguished between games that use intrinsic fantasies and extrinsic fantasies (see chapter 1) and suggested that games which employ extrinsic fantasies can be superimposed onto a curriculum where the player works towards a fantasy goal. Alessi and Trollip (1991, p. 182) in their excellent book on computer based instruction mention the idea of templates or template games. They state that "these are games whose form lends itself to being used in a variety of areas". They give a good explanation of the of the games as being easy to reproduce and apply in a variety of contexts or subject areas. However this is too vague a definition for their inclusion into existing instructional formats such as tutorials or drills. Rieber (1996) further clarifies fantasies as being either endogenous or exogenous to the game's content. For games which use exogenous fantasies (e.g., Hangman) they are independent of the courseware content and any content can be superimposed on top of this fantasy. Furthermore, Rieber considered exogenous fantasies to be the educational "sugar coating". Rieber (1996) stated that games which employ endogenous fantasies weave the content into the game. The user doesn't know where the game stops and the content begins.

Exogenous games are therefore defined as games which are independent of the courseware, with simple formats and that employ exogenous fantasies. Endogenous games can be considered to be games which are dependent on the content of the courseware and that employ endogenous fantasies. These games are usually more complex in nature and need to tailored specifically to the subject being learnt. An example of an endogenous game would be Heartpin (Microsoft, 1996). In this game, the pinball S&A game is used to show how blood flows through the heart. The student uses the paddle at the bottom of the screen to hit the ball past the valves of the heart in the same direction as the blood would flow in a real human heart. Unfortunately, it is very difficult to transfer these games onto other subject areas. Both endogenous and exogenous games can promote the use of intrinsic fantasies as well as extrinsic fantasies.

The term endogenous game has been used since Rieber's (1996) paper without supply of a formal definition (e.g., Jones, 1997).

Jones (1997, p. 5) stated that one point the Rieber did not raise in his article was that "in endogenous games, the key to creating a learning environment is the environment itself. The environment is more than simply the sum of separate parts, but it is and entity in and of itself". The author agrees with Jones in the sense that if the game is the teaching tool, then we can consider the game as an "entity in and of itself", but when the endogenous game is used in a larger context, it remains as a separate part of the whole learning "microworld". The learning should be an explicit understanding of the whole learning session, where objectives set out in the session have been fulfilled by the student. Learning through the use of an endogenous game is discussed below.

3.6.1 Research on Endogenous Games

In their study, Rieber & Noah (1997) investigated the influence of game-like activities and graphical organisers on adult learning during a computer-based simulation. In an analysis of both quantitative and qualitative results, they found that by introducing a gaming context for a physics simulation, subjects' intrinsic motivation increased. While the participants' scores increased with practice on the game, promoting tacit learning of acceleration and velocity, the gaming environment did not promote reflective cognition. In fact, it interfered with explicit learning of the scientific concepts. Participants were lees able to answer the questions that relied on explicit understanding of the physical relationships at work. Subjects in the gaming group also reported lower response confidence and perceived comprehension. The gaming environment promoted experiential cognition (as subjects were highly engaged in the game), but reduced reflective cognition. This is in agreement with previous research on this topic: when game-like activities (in physical sciences) are given to subjects, they "have great difficulty in transforming this experiential (or tacit) knowledge into an explicit understanding of the scientific principles (as measured by traditional performance tests, such as post-tests) (Rieber, 1996; Rieber et al, 1996)" (Rieber & Noah, 1997, p. 9).

For reflective cognition to occur, the student must be able to distinguish the experiential nature of the game from the explicit learning of the material. It is the opinion of the author that the endogenous simulation game in Rieber and Noah's (1997) study, causes the user to divert attention from the learning of the concept to the playing of the game. The game may require too much of the user's attention and working memory, thus reducing the ability to memorise the target concepts to be learned. Moreover, due to the close interwoven nature of the courseware content and the simulation game and the time spent playing the game component, the student lacks the ability (i.e. the time) to ask the question 'why?'. It appears that procedural knowledge gained by playing the game has played a more dominant role than the declarative learning. This means that the mastery of the game has taken precedence over the mastery of the explicit concepts within the game. There are various implications for this study within instructional design. It appears that games, which involve a high level of engagement, improve motivation, but not explicit learning.

Having implicit knowledge about a subject often means that the individual is inherently good at a task, using the relevant skills to a sufficient manner. However, when playing games, the mastery of such implicit learning of the concepts and being able to explicitly define what was being learned is very difficult. Gagné (1977) suggests that for true learning of verbal information, the student is able to "state it". This is difficult when playing a game as the concepts used within the game are not explicitly defined or learned as explicit knowledge. Moreover, with the pragmatics of designing engaging games, it is often difficult to see how it teaches the information.

Merrill (1996, p. 6) states that "There are known instructional strategies. The acquisition of different types of knowledge and skill require different conditions for learning (Gagné, 1985). If an instructional experience or environment does not include the instructional strategies required for the acquisition of the desired knowledge or skill, then effective, efficient, and appealing learning of the desired outcome will not occur."

To overcome the problem of designing an instructional game that includes the necessary instructional strategies, a model is proposed for inclusion of exogenous games that can solve both the game design problems i.e. the time and effort of designing a new type of game and the instructional problems i.e. where exogenous games can overlay existing instructional formats that already include the necessary instructional strategies for the desired learning outcomes. This model is proposed in Chapter 4.

Chapter 4: Designing Instructional Software with the Inclusion of Exogenous Games

4.1 Exogenous Games

As stated in Chapter 3, exogenous games are games which are independent of the courseware design and employ exogenous fantasies. Due to their simplicity of design and reusable nature in any context, the author proposes that exogenous games can be inserted into existing instructional formats as aiding or providing the appropriate instructional events. The model for inclusion of exogenous games into a tutorial structure is given in Figure 4.1.

Two instructional formats, tutorials and drill and practice software, are considered for inclusion of exogenous games because of their prevalence within educational software and their easily defined configuration. In 1985, the most common educational packages for young learners included the drill and practice software and the computer based tutorial (Bialo et al, 1985). Drills accounted for 50% of the educational programs, whereas tutorials accounted for 19%. The tutorial design usually involves three events of instruction: presenting information, testing knowledge and providing feedback. However Gagné et al (1981) suggest that the design of these programs can be extended from three to nine events of instruction. Drill and practice software usually involves only two events such as testing knowledge and providing feedback. The next section in this chapter looks at various insertion points for the exogenous games corresponding to Gagné's instructional events and links them to the considerations when designing a computer-based tutorial.

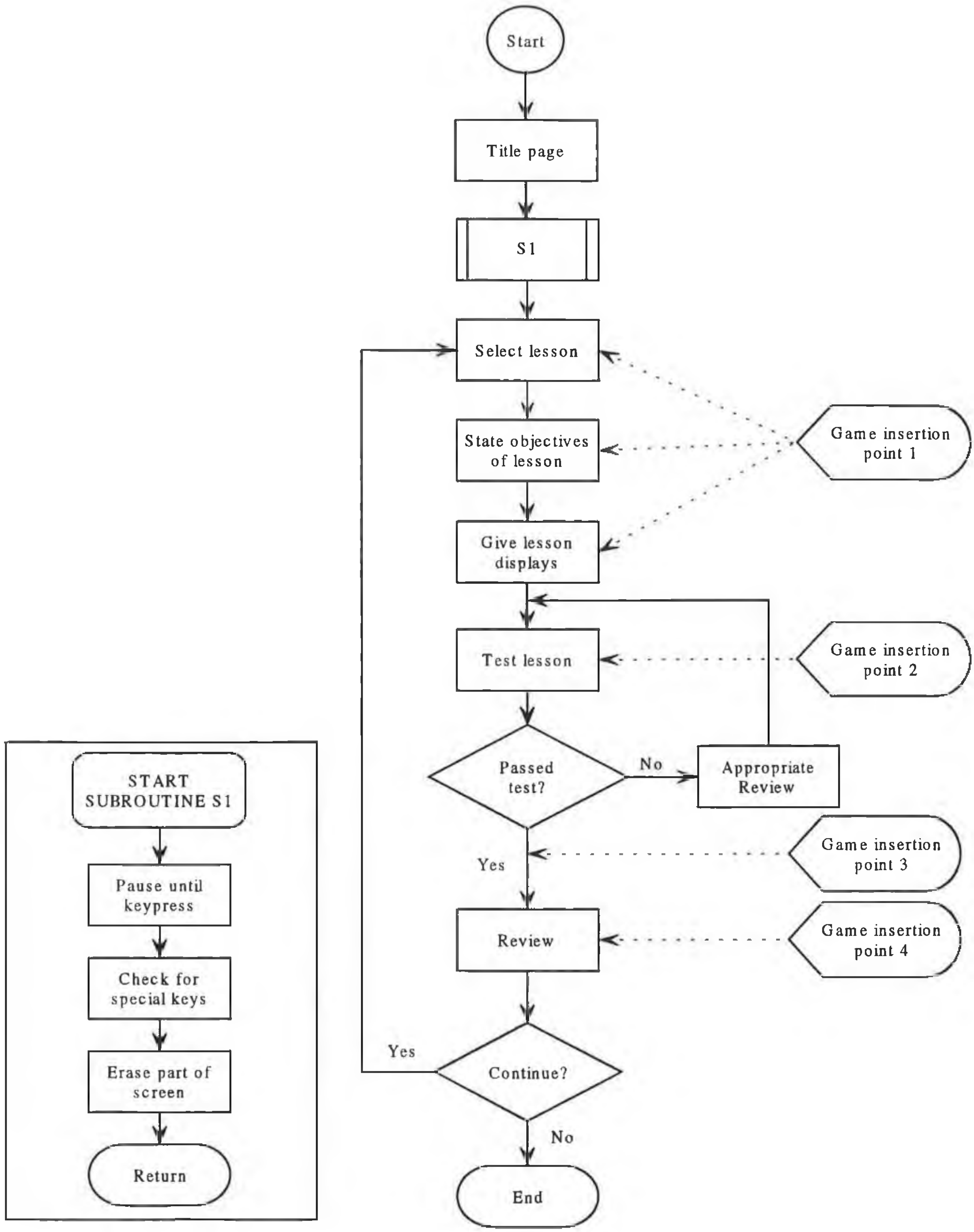

Figure 4.1 Tutorial structure with proposed insertion points for exogenous games

4.1.1 Games as Engaging Environments

Firstly, it is proposed that this tutorial format can be incorporated into an exogenous game. The structure of the tutorial remains intact, but is inserted into a larger gaming environment. Drill and practice programs are considered as referring to the testing phase of the tutorial as they refer to Gagné's (1977) instructional events of eliciting performance and providing feedback. The exogenous game provides the fantasy world in which to embed the courseware and the testing environment. Playing the game engages the student and focuses attention, thereby facilitating both psychological and physical immersion (Wynn & Oliver,1996). The game gains and maintains the attention of the student with the graphical displays and interactions with the user. This may be of the form of text, graphics or both, in two or three dimensions. While playing the game the student's sensory and cognitive curiosity is maintained by the nature of the game itself (Malone, 1981). The drills or tutorial pieces are embedded into the structure of the game and appear at various stages as obstacles or challenges to be overcome. The student must pass these obstacles to continue playing the game. It is possible that each of Gagné's instructional events can be included as part of the game storyboard and scenarios.

The engaging exogenous game can present an opportunity for the presentation of the subject matter as well as the testing sections (as found in drill and practice software). For instance, in an adventure-game tutorial, the user could explore the microworld for information pertaining to a larger subject area (e.g., a piece of a mathematical formula could be given when finding new information and then used to work out problems later during the game). The game, therefore, holds all information necessary for the learning of the subject matter. With an adventure format, the student can travel to various places and receive information from discovering items contained in the landscape or from other characters within a story. The student assumes the identity of a character inside the game (thus promoting immersion and fantasy), makes choices and follows a particular path of discovery. Maze games and Platform games can also be used in this way (see Figure 4.2).

Theses games have often been used for drill and practice programs, as the testing format is easily inserted at various points inside the game.

Figure 4.2. Screenshot from Word games at Camelot from Adventure Learningware.

Word Games at Camelot is an excellent example of how the platform game can be used as an environment for drill and practice sections. In this vocabulary learning game, the user assumes the character of a knight on a quest to join the knights of the round table. The knight must collect items for points (e.g., shields), avoid enemies, and answer the questions posed by the guards at various stages in the game. The questions refer to the use of the vocabulary words in context. Each level has either four or five guards and each guard asks five questions. To finish the level in the game, the student must answer all the questions posed by the guards to achieve a required percentage of correct answers. The display at the bottom of the screen shows the student score, the health of the knight, the present level, the number of correct and incorrect answers, and the target number of correct answers needed to progress onto the next stage. The program can record the students names, scores, and also the number and type of answers given. A report can be printed at the end of the game with the relevant details of the student's performance during the game. Before playing the game, the student can input his or her name, the level of difficulty and speed of the game. The teacher has control over the percentage of right answers needed to pass a level in the game. The teacher can also vary the courseware content, changing the number and difficulty of the questions and the level settings. The format of the questions can also be manipulated. The student can be required to pick a word corresponding to a definition, pick a definition corresponding to a word, or complete a sentence with an appropriate word from a list.

4.1.2 Insertion point 1:

Apart from having the game as the primary focus of the student and including tutorial elements, exogenous games can be inserted into the existing tutorial and drill software. After the title page, the user begins with a selection of what lesson is to be studied, learned, practiced or tested. At this point, the game format can be used to select the lesson and receive information about the various sections of interest. For instance, a selection game can be used to choose a lesson with the lesson objectives displayed as a result of being picked by the user. Games in this phase of the tutorial refer to Gagné's first four events of instruction. This include gaining the attention of the user, informing the learner of the lesson objectives, stimulating recall of prior learning, and presenting the information. This is indicated on Figure 4.1 as encompassing the selection of the lesson, the objectives, and the presentation of the lesson displays. The purpose of the games is to get the student to interact with the learning environment, heighten motivation and arouse curiosity. The ability to select the lesson (or parts of it) promotes learner control as the student is then able to control the presentation of information (Kinzie, 1990). For this reason exogenous games included at this stage in the tutorial structure will be referred to as presentation games. Examples of games in this category include search games, shootem'ups (e.g., point and shoot), and maze games. For search games, the user must locate sections on the screen and then click on them to reveal sections. With the time need to locate sections of the screen, the student is increasing their time-on-task, thus improving reflection. Care should be taken as to how long the students take to locate a given topic. If the time taken is too long, the tutorials or drills will not be finished in time.

Therefore, this type of game needs to be tailored with respect to the age and level of competency of the learner.

4.1.3 Insertion point 2:

After the presentation of the courseware to the students, the next step is to test the user's understanding of the lesson. This directly relates to Gagné's instructional events of eliciting performance and giving feedback. This is indicated on Figure 4.2 as the testing phase. At this point, the purpose of the exogenous games is to heighten motivation of the student. Three types of exogenous games that can be included during the testing phase are proposed. These include *novel-answering games*, *time-based games*, and *score/achievement-based games*. In *novel answering games*, the student is given an interesting way of selecting answers from multiple options. The games scenario provides the user with examples as well as non-examples or arbitrary stimuli in which the student must select the correct answers (see Figure 4.3). Examples of the types of novel-answering games include shootem'ups, point and shoot games, search games and match games. With match games, for example, arithmetic skills can be tested (see Figure 4.4). Match games can facilitate the practice of learning outcomes such as rule following since objects can be matched or grouped according to defined rules.

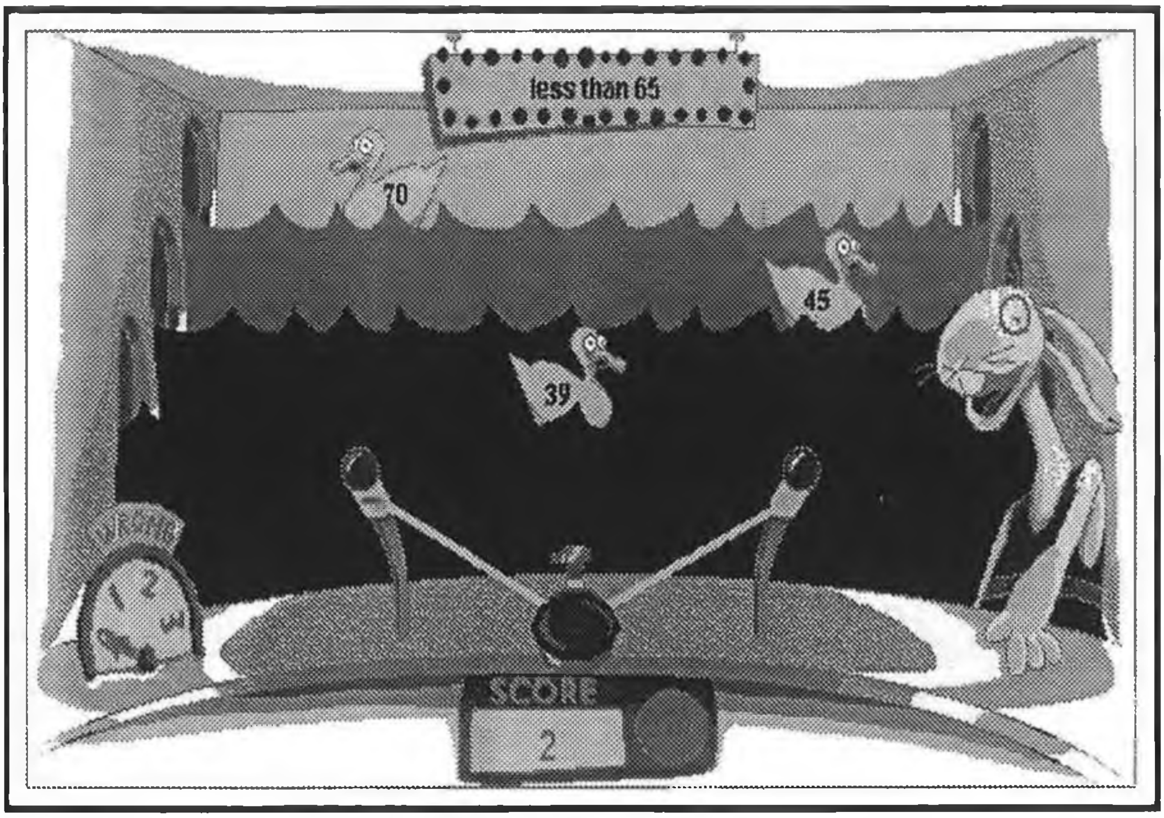

Figure 4.3 Screenshot from Duckshot. This game uses the theme of a fairground attraction i.e. Shoot the Duck, as a way of getting the user to select an answer in a novel way. The idea is to draw back the catapult with the mouse and shoot some water at the ducks with the correct answers in response to the statement at the top.

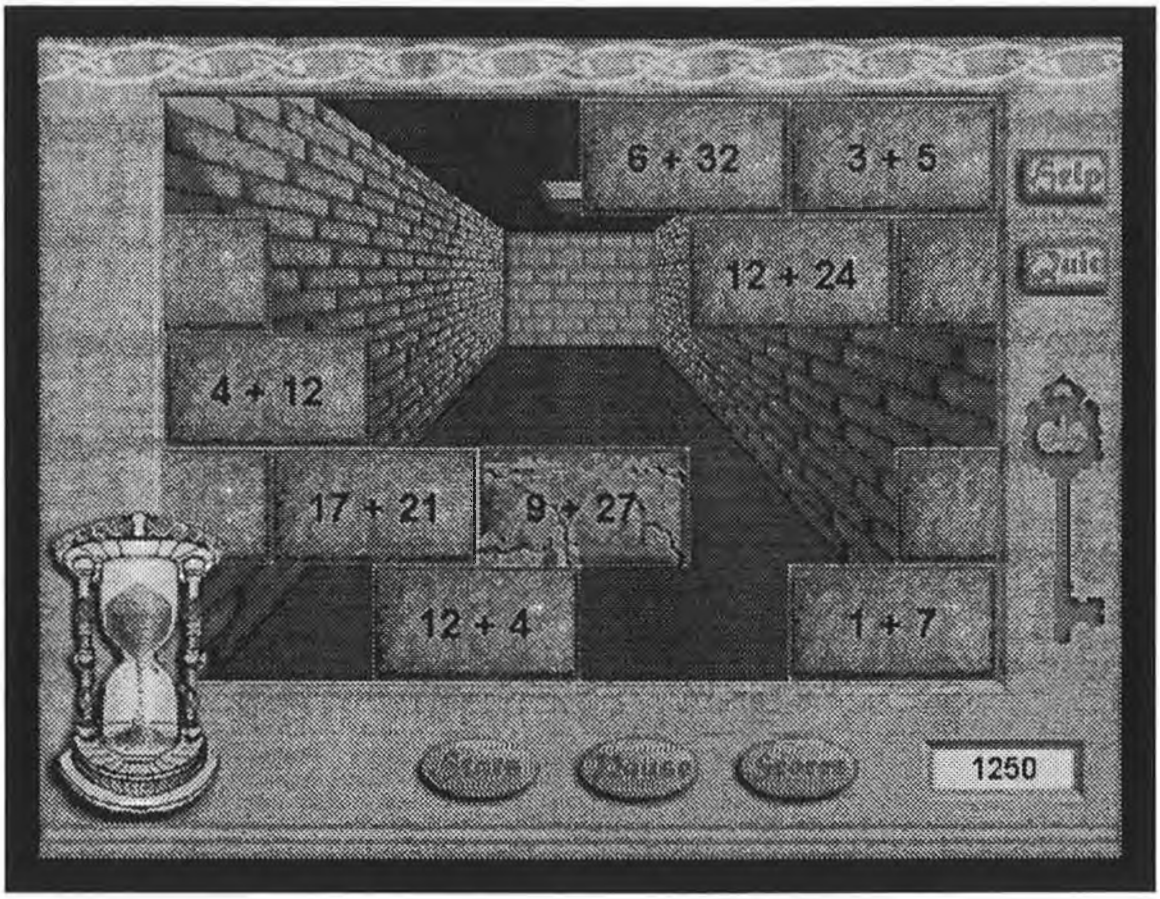

Figure 4.4. Screenshot from "Break the Wall" illustrating how a match game can be used to practice/test arithmetic skills. The bricks disappear when matched with a similar numeric value within a given time constraint. When all the bricks are destroyed, the user moves down the corridor to the next wall.

The second type of testing games are *time-based games*. Here, the student is motivated to answer questions within a specified time constraint. The time constraint can be demonstrated by some graphical display (e.g., animation of an hourglass) or textual countdown. This may take the form of answering the questions to rescue objects or characters displayed on the screen (see Figure 4.5). Another type of time-based game involves using the speed of the user's input as a means to achieve some greater goal. This may be an increase in score of the display of a fantasy scenario. For example, a race game could be used to motivate the user to answer questions within a specified time limit. By accurately and quickly answering the questions the student's vehicle would advance towards the finish line. The opponent's progress in the fantasy scenario could be a previous player's times or some computer-generated opponents.

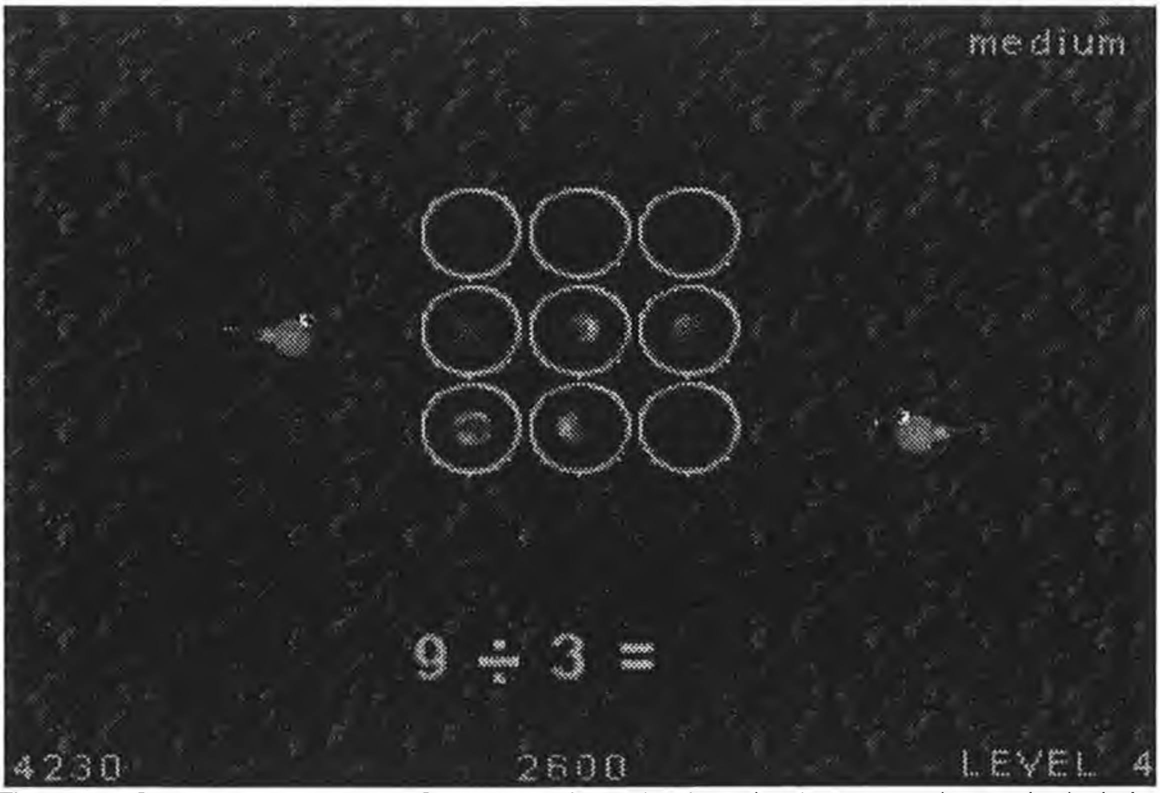

Figure 4.5. Screenshot from "Math Snatchers" illustrating how the time constraint can be included in the testing phase to heighten motivation. The animated characters (or snatchers) on the screen move towards the blobs in the boxes (given to the students for correct answers). By answering the next question quickly, each snatcher is made disappear. The user cannot move on to the next level unless they answer all the questions correctly.

The third type of testing game involves using the player's achievement when answering questions to further achieve a play-goal or extrinsic fantasy. This can be done by awarding a number of points for each correct answer, comparing a score with a highscore, or using the player's achievement to enable the student to play another game that is running simultaneously during the testing phase. For example, a correct answer could enable the student to play a move in Tic-Tac-Toe (Naughts and Crosses). Another example is to allow the student remove a piece of a puzzle for each correct answer. Frame games are easily used in this way, whereby a correct answer would enable the user to progress in the game.

4.1.4 Insertion point 3:

At the end of the testing phase it is proposed that exogenous games can be used as a source of reward for achievement. This is indicated on Figure 4.1 (p. 60) as occurring after the testing phase has been successfully completed. Reward games mainly refer to two of Gagné's instructional events such as providing feedback and assessing performance. If the results of the testing phase were found to be acceptable and no further remediation being necessary, reward games can be inserted into the program structure as a means of contingent positive feedback for achievement. As well as the reward for good performance, some positive rewards should always be given to the student irrespective of their achievement to ensure that the less capable learners will not become disheartened. Credits can be earned for scores gained during one or more testing sessions. In this token economy system these credits can then be used in exchange for time on a game, number of lives, or choice of a number of games (see Figure 4.6).

A reward game can be any game which is engaging for the user, has a relatively short duration and has parameters (e.g., number of lives) that can be altered. These may or not be educational. S&A games, for example, are ideally suited because of their fast pace and alterable elements. A computer version of a chess games would, for example be a poor choice for this purpose because of the long length of time needed for completion of the game. Some strategy games are also applicable as reward games (e.g., jigsaws). At this stage, the program can provide multiple games of different types to suit the user's preferences. Providing choices within the educational package gives the user more control of the program, and thus improves intrinsic motivation and satisfaction (Kinzie, 1990; Keller, 1987; Wynn & Oliver, 1996).

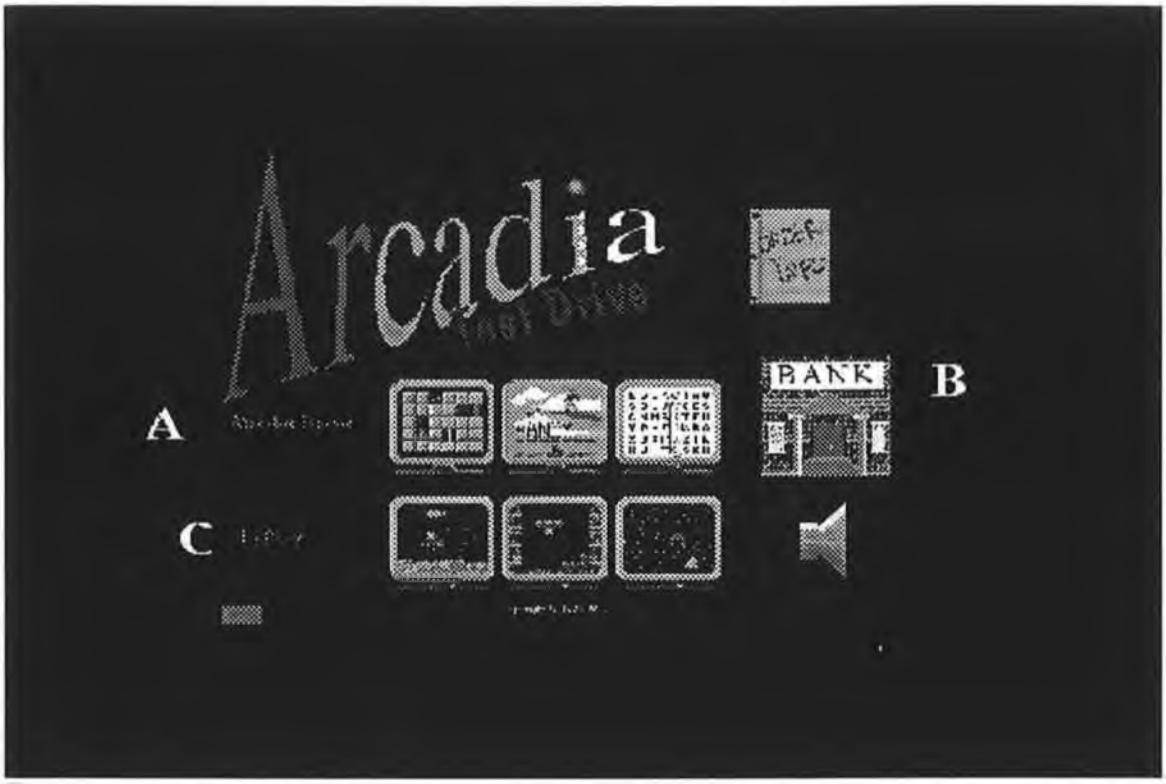

Figure 4.6. Screenshot from "Arcadia Learning". This shows how a token economy system can be used to facilitate play of rewarding games. Point A shows the educational games to be played first of all. Credits are gained for completing each educational game and the amount of credits earned can be checked at the bank (point B). Point C indicates the reward games made available with a minimum amount of credits.

Reward games should only require a short amount of time to complete. This is to reduce the Nintendo effect. The Nintendo effect occurs when the game becomes the goal of the exercise and the focus of attention shifts from the learning and retention of the courseware to the quickest possible route to play the game. Providing a minimum target number of correct answers helps reduce this effect as does providing a minimum time to go through each of the presentation screens. The game should not become an end in itself (Alessi & Trollip, 1991). It should not take away from what is being learned, rather, it should act as an incentive to acquire the learning material and perform well during the testing phase.

4.1.5 Insertion point 4:

At the end of the program, it is proposed that exogenous games can provide a summary of concepts learned throughout the computer-based tutorial or drill. This is indicated in Figure 4.1 (p. 60). The purpose of games at this stage is to enhance retention and transfer of learning corresponding to Gagné's last instructional event. Types of exogenous games applicable to this stage in the learning process include word games, modified shootem'ups, and match games. Various keywords are taken from the courseware and displayed during the game as a means of reflecting on what has been learned earlier in the session. For the more advanced programs, the students's incorrect answers could be addressed by including the relevant keywords or displays and displaying them again within the game. Word games such as Hangman, Scrabble, Crosswords, conundrums and word searches have often been used for this purpose. The format of the Hangman games can easily be altered to be used in several contexts, whereby a wrong answer to a problem would at a piece to the hangman structure (Alessi & Trollip, 1991). This is also true of the shootem'ups. The Metric Arcade (Lionet and Lamoureux, 1994), is an example of a fast-paced reflective game (see Figure 4.7). This game uses a Space Invader theme with characters corresponding to different metric measurements. The target number is displayed at the bottom right-hand corner of the screen and the user must shoot the corresponding word or letter. The content could easily be altered to facilitate varying subject matter. Match games are also used as a method of promoting reflection and practice of key concepts. A summary of the types of exogenous games are given in Table 4.1.

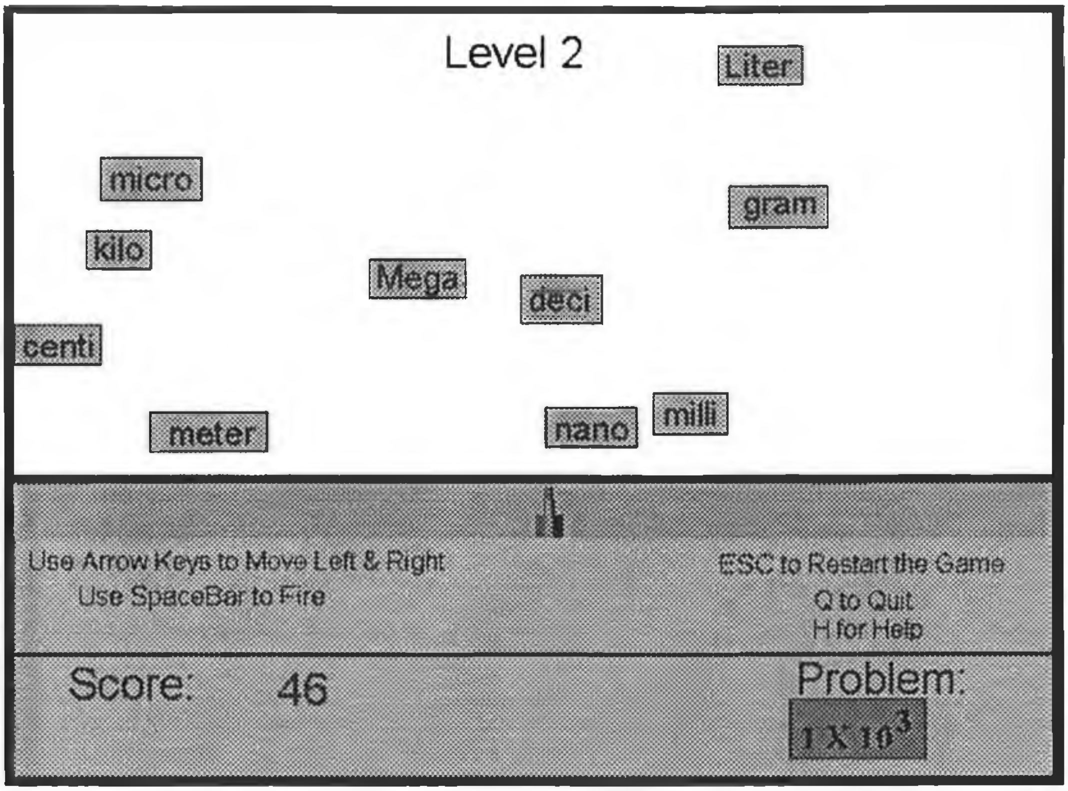

Figure 4.7. Screenshot from the Metric Arcade. The Metric Arcade. Created with Klik & Play ©, by Francois Lionet and Yves Lamoureux (1994). The idea is to shoot the boxes with the word corresponding to the numeric value displayed in the bottom-right corner of the screen. The challenge is heightened as the boxes move in a random path around the screen. The score is increased with every shot on target and decreased with every miss or wrong target hit.

Gagné's Instructional Events	Exogenous Game Types	Examples
• **All events**	• Engaging games	• Adventures, Platforms, Maze games, Frame games
▫ **Gaining Attention** ▫ **Informing Learner of Lesson Objectives** ▫ **Presentation of Stimulus Material** ▫ **Guiding learning**	▫ Presentation Games	▫ Search games, Point and shoot, Match games, Frame games
▪ **Eliciting performance** ▪ **Providing Feedback**	▪ Testing Games: 1. Novel answering 2. Time based 3. Achievement/Score based	1. Point and shoot, search games 2. Race games, Rescue games 3. Puzzles, Race games, Simultaneous games (e.g. chess, board games)
♦ **Providing Feedback** ♦ **Assessing Performance**	♦ Reward games	♦ Any non-violent Skill and action games, Puzzles
• **Enhancing Retention and Learning Transfer**	• Reflective/ summary games	• Word games, Point and shoot, Match games (Card games)

Table 4.1 Summary of Exogenous games and their use in the instructional process

4.2 Considerations for the design of Tutorials and drills

4.2.1 Gaining Attention

An important factor in the design of any educational program is the first impression the user has and general neatness of the package (Jones, 1997). Typically, educational programs begin with and introduction screen, which displays the title of the program and authoring company. Some display text only, others have both graphics and text, and some have animated graphics. The purpose of a title screen is to attract the student's attention, to create a receptive attitude and to indicate in general, what the lesson is about (Alessi & Trollip, 1991). Sometimes the user is required to press a key (or click the mouse button) in order to continue onto the next screen. It is more usual to press the return key or space bar as they are most easily recognised by the user. For all outcomes of learning (verbal information, intellectual skills, cognitive strategies, attitudes or motor skills) "attention of the students is gained by introducing rapid stimulus changes." (Petry et al, 1987, p. 16). For computer based instruction, this can be facilitated by changing the visual or auditory displays (Petry et al, 1987; Mayes 1994). The interface design for maintaining this attention can also be tailored to suit the needs of the user. This is necessary for students of different ages and levels of competency. For young users, the interface can be designed to focus their attention on various points on the screen when required. In one drill and practice program (Adventure Math) a large red arrow points to the position on the screen where attention is most required (see Figure 4.1). For older and more familiar users, this may not be necessary, as they are less likely to lose concentration.

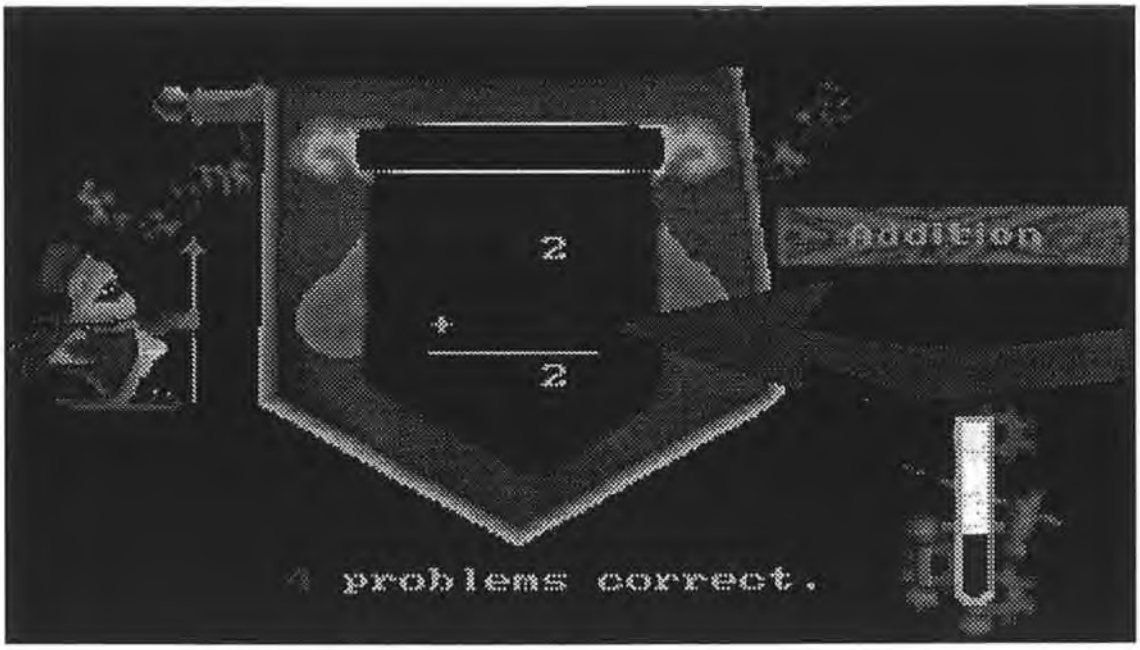

Figure 4.1. Screenshot from Adventure Math illustrating how attention can be focused to one section of the screen for younger students

4.2.2 Controls

At the beginning of a computer-based lesson it is necessary to demonstrate how the student can interact with the program. This may involve using the keyboard or mouse to communicate with the program. For example, the mouse can be used to click on various parts of the screen such as a menu-bar or some intuitive buttons to press such as arrows depicting back and forward through the screen displays. The keyboard can also be used to input information and navigate throughout the program. It is important that the procedure for answering questions should be clear and simple for the user. This is especially true for younger students who often find the mouse double click, for example, difficult to master. Moreover, the use of the mouse by students, for example, as a tool to either click on objects or drag and drop items can play an important role in the students' preferences (Inkpen et al, 1996).

An option screen allows to the user to adjust the various settings of the program. This gives the learner some control over his or her learning. Some of the features of the program (such as the speed, sounds and volume) can be adjusted by the student. Other program can be designed to branch to easier or more difficult material based on a continuous diagnosis of input data." (Schaefermeyer, 1990, p 11). Branching helps to individualise the program to better suit the learner's needs and is used as the user progresses through the program.

4.2.5 Giving Objectives of the lesson

The next screen presents the various topics to be covered. When a topic is selected by the student, another screen appears with the objectives of the lesson. This ensures that the user has an overview of the information that he or she will be learning and how it is incorporated into the overall subject theme of the tutorial. These should be clear and unambiguous to promote understanding and increase the relevance of the material to the student. The objectives of the lesson can be described in behavioural terms by giving a statement of the conditions which the target behaviour should occur, a description of the target behaviour required and some criterion for acceptable performance (Alessi & Trollip, 1991). However such a detailed list of objectives may be inappropriate for very young students.

The lesson can be presented via a series of multimedia displays including text, graphics, audio and/or video. The interface design should be consistent throughout the sessions for ease of understanding and use. The presentation of information to the student and all corresponding content can be contained in various multimedia files independent of the interface design. This introduces some flexibility into the program as the content of the tutorial can be easily changed by the teacher. For each screen presented, the author should determine if words, illustrations or icons are most appropriate (McFarland, 1995). The student should be able to interrupt the program (i.e., pause) at any stage.

4.2.6 Testing

The testing phase typically follows the presentation of the courseware material. The questioning format can reflect the student's ability and learning style. For example, people who use abstract conceptualisation as their style of learning can have problems with multiple choice questions as they tend to see how the other answers given may be correct as well as the target answer. If the answer selected by the student is wrong, the appropriate feedback and remediation should be contingent. The positive reinforcements of correct answering can be gradually reduced to promote reflective cognition and increase cognitive responsibility (Sedighan & Klawe, 1995)

The student should be able to navigate between screens easily. A menu driven system (Gold 1984) allows the user immediate access to the portion of the program to be used. This reduces the time wasted on irrelevant or undesired sections of the program. This can be made available to the user at every stage of the program's operation. This may be made continuously available by having pull-down menus, pop-up menus or by keyboard numbered menus (Schaefermeyer, 1990). A save feature can be used by the student to return to the same section of the program, during the next computer session.

4.2.7 Reports

At the end of each section a report card can be shown to the student to review his or her progress. This should help in debriefing the student at the end of the computer session. When leaving the computer program, the users position in the program should be saved along with their score and level settings. This makes it easier for the student to continue where ended in the previous session.

Chapter 5: Discussion and Conclusions

The purpose of this thesis was to ascertain the role of computer games in education. Various theories of instructional and computer game design were discussed with respect to maintaining the interest of the student while performing the computer based tasks. For this reason a taxonomy of games was developed to ascertain the educational applications of various types of games. Furthermore, the elements of the games that maintain the users' interest or motivation were looked at in detail in chapter's one and three such as Malone's theory of Intrinsically Motivating Instruction (Malone, 1981) and Wynn & Oliver's (1996) IMM learner effects.

The proposed model stresses the inclusion of games to facilitate increased motivation by engaging the user, promoting sensory and cognitive curiosity, providing for reinforcements, rewards, feedback, intentional and incidental learning, and promoting implicit as well as explicit learning of concepts. Exogenous games, because of their easily defined format and reproducibility, are ideally suited for overlaying existing instructional formats. Also the retention of the instructional events in existing instructional formats, means that the pedagogic role of the games does not reduce the instructional value of existing CAI applications.

The model for inclusion of exogenous games was based on Gagné's Instructional events, behaviourist theories of reinforcement and motivational models. In summary, it was stated that exogenous games can be inserted into existing tutorial and drill and practice software in five main ways.

- Games can be used as encompassing the whole tutorial format at various points inside the game.
- Exogenous games can be inserted as the presentation phase as a means to focus attention and reflection of the material.

- Exogenous games can be inserted at the testing phase as a means of heightening motivation to perform well.
- Rewarding games can be inserted after the completion of the testing phase as a means of positive reinforcement.
- Exogenous games can be inserted at the end of the computer based exercise as a means to promote reflection of the main concepts of the courseware.

There are various parameters that can be altered for each type of exogenous game. These include the fantasy, challenge, curiosity, control, immersion, and complexity elements. Each element has many sub-factors. For example, the challenge component includes goals, uncertain outcomes, variables difficulty and varying levels of competence. Although the element of challenge has been considered by some authors to be the most crucial factor, controlling for, or measuring the effectiveness of each of these elements is an almost impossible task (Baltra, 1990; Cited in Dempsey et al, 1993). As Dempsey et al, (1997, p. 2) state "much of what occurs in a gaming environment may not be easily measurable or, at least easily reduced to a few variables. The validity of the assessment of an instructional game is quite different from other learning environments and, according to Reuben & Lederman (1982) is dependent on rules, interactions, roles, goals, and criteria. Therefore, although experimental studies have an important place in the instructional gaming literature, there is a budding movement to recognise the limitations of objective-oriented research for assessment and look at the effects of incidental learning as well as incidental learning (Barnett, 1984; Remus, 1981)." Bredemeier & Greenblat (1981) suggest variables that affect the outcome of studies on effectiveness of games. These include cognitive styles, personality, academic ability, game ability and administrative variables.

Therefore, testing of this model is a rather difficult task. There are however, a few limitations when considering the insertion of games within existing educational formats such as drills or tutorials. Firstly, the oversupply of extrinsic reinforcers, such as the games can reduce or undermine intrinsic motivation (Alessi & Trollip, 1991). It is therefore suggested that the exogenous games should not be included at every stage in the learning process. The continuity of the graphical displays, or neatness, is essential and the games should distract the student's attention from what is being learned (Dempsey et al, 1997, Jones, 1997). The possible exception to this rule would be in the case of rewarding games. These games should be short in duration to minimise the Nintendo effect.

It is proposed that the inclusion of exogenous games may be most beneficial for younger age groups (such as primary schools) and special education for a number of reasons. Firstly the inclusion of games to aid learning is often more distracting for adults as their level of intrinsic motivation to learn is often much higher. The use of games or elements of games within CAI often targets the affective domain rather than the cognitive (Wynn & Oliver, 1996). This is especially true for students with motivational or attention problems. Therefore, the author suggests that the real value of this model lies in the use with children of primary school age and students with special needs.

With the advent of web-based instruction via the internet (e.g., K-12), and the use of Java programming and authoring packages (e.g., Macromedia Shockwave) to produce games that can run on the user's browser, means that instruction via the internet has now become more interactive for the student. Traditional browsing through instructional web pages can be a monotonous procedure. This model illustrates just how exogenous games can be used within web based instruction to maintain the interest of the students.

5.1 Future research

In the proposed model, the weighting of the gaming content may change with the age of the student being taught. Finding the right formula of amount of gaming with formal structured learning could give an insight how this can be achieved. However with the diversity of game types and game elements this becomes a complicated task. Such a large undertaking is beyond the scope of this thesis.

The games used at the various stages in the instructional process could be tailored to the learning styles of the students. As Dempsey et al, (1997) noted, different learning styles showed differences in gaming preferences and perceived optimism. With this in mind, designing computer based educational software with some gaming elements needs some research into how best to tailor the gaming content for maximum motivation to learn. This is especially true for student with special needs.

The role of endogenous games is also a current focus of research, especially in the areas of promoting reflection and tacit (implicit) learning through play (Rieber 1996, Rieber & Noah, 1997). Microworld programming and constructivist principles (e.g., LOGO, Papert, 1980) have become more commonly used as a method of promoting student learning. Instead of the 'instructionalist' frameworks, the students use the multimedia authoring software as a means to program their own applications. Bates (1996) maintains that student's learn more from constructing their own multimedia than from browsing through commercial multimedia. A possible balance between instruction and construction of learning could be found by giving students all multimedia information and getting them to use such information to produce gaming software.

5.2 Designing the ultimate educational game

With developments in computer game design and theories of learning, more complex interactions can occur with the user and the computer. It is possible to further explore the use of reinforcers in visual, auditory and tactile formats. For visual elements, the use of 3-D graphics can further immerse the student in the computer simulated world. The use of non-speech auditory cues has hardly been touched on in the literature (Mayes, 1994). A possible avenue of research may look at the use of sounds as feedback within games and look at the effects of varying the elements such as the duration, pitch, and tone to see what effects they have on learning. Moreover, the scheduling of auditory cues could also be looked at to find some effective strategies for their inclusion into computer game design. The use of tactile feedback is often used in the newer Arcade games. The user's input device is more integrated with real life. This can be seen in racing games where the user can be seated in a car, on a motorbike, in a tank, and even on some skis.

The design of educational games however, should not be lead by developments within the technology. As Bates (1996, p. 37) states "Pedagogy leads and the technology follows! Thinking about computers in education means thinking about education not thinking about computers." Instructional designers should not 'push the envelope' when design educational software (Jones, 1997). A simple 2-D game design is often more beneficial and more educational than a complex technologically impressive 3-D virtual world because of it's ease of understanding and use. Nevertheless, educational games that are pedagogically sound (i.e. include all instructional events and strategies for learning outcomes) may not necessarily be effective if the motivational and affective aspects in their use is not addressed.

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