

Learning from Television:

A study of the effects of different levels of explicitness and the influence of spatial ability on learning of visual concepts and principles

by

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Abstract

This study explored the effects of the degree of explicitness used to show movement and manipulation in teaching visual concepts through television. The review of the relevant theories highlighted the importance of individual differences in cognitive processing skills. The research question was formulated in terms of an aptitude treatment interaction. The aptitude of spatial ability was expected to interact with the level of explicitness of moving visual sequences. A sample of 200 school children were divided into a control and two treatment groups. Spatial ability was measured using a paper-folding test. The two television treatments, explicit and implicit, varied as to the degree of movement used to illustrate visual concepts and processes. An immediate comprehension test revealed no differences between the treatment groups. A test of retention administered three weeks later, showed a significant difference in favour of the explicit group. Spatial ability was shown to be a significant moderating variable on both tests. No interaction between the variables was found.

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Chapter One - The Problem

The Context of the Problem

Learning from television is becoming an increasingly significant aspect of the modern education scene. Recent technological developments in satellite and cable distribution, video recording and video disks have all further enhanced the potential of instructional television. Modern transmission techniques are making television more immediate and accessible to viewers. In the next few years, digital technology will bring high definition television, using over 1,000 lines of resolution instead of the present 625. The advent of interactive television will change the way we use the medium, giving the viewer greater control and selectivity. All of these developments offer significant opportunities for all areas of education.

The way we use television for educational purposes can have important influences on the global distribution of knowledge. A mediated rather than interpersonal approach to the delivery and support of instructional messages enhances the possibilities of open learning, continuing education and education in developing countries. The concept of distance education is both exciting and challenging and the full pedagogical, socio-cultural and economic potential of modern television technologies has yet to be realized.

The relationship between communications technologies and the technology of education has been unfolding for many years. Since 1500 the printing press, a technology developed

for the dissemination of information in textual and pictorial form, has been the predominating means of mass communication applied to learning and teaching. In the twentieth century, new audio-visual technologies using combinations of speech, other sounds, still and moving images, have provided a new language of communication.

Electronically based visual communications are transforming our information gathering and learning methodologies. Whether broadcast to a television set or generated by a computer, electronic imagery has become our dominant new communication form (Adams, 1987). The consequences of this, for education in general and learning in particular, need to be assessed.

The use of television to teach concepts and principles in science and in related areas, has been advocated on numerous occasions (Gagné, 1970, Allen, 1967 and Schramm, 1977). Teaching through television is often advocated when the concepts involved are visual in nature and when the principles relating these concepts are dynamic. According to the (British) Open University Broadcast Sub-Committee (Bates, 1981 p 9) the educational functions for which the medium of television is especially suited, include

"To illustrate principles involving dynamic change or movement

To illustrate principles involving two-, three-, or n-dimensional space

To use animated, slow-motion or speeded-up film or video-tape to demonstrate changes over time "

Dwyer (1970a, p 289) also refers to the visual power of television

"It can be used to portray information in almost any subject area, to illustrate large amounts of information visually, compress information, illustrate the more salient parts of a presentation, and clarify and expand difficult concepts and manipulative techniques "

Sequences involving animation, working models and transformations in space and time are used extensively in educational television programmes. How these should be structured and presented to facilitate optimum learning is an important question.

Statement of the Problem

Modern computer graphic and animation systems are capable of generating complex visual sequences for use in television production. Today, television producers can present visual concepts and principles with more movement, more sophistication, greater definition and more realism than ever before. However, research has shown that increased detail and elaboration in visuals does not necessarily produce a proportional increase in student learning (Dwyer, 1970).

This study investigated the instructional value of explicit movement and manipulation in visual sequences used for teaching science through television. The problem of how much movement and manipulation should be used to represent a particular process or to show a particular transformation in space or time, was addressed. Producers of educational

television have the equipment and the technical expertise to produce elaborate visual sequences. However, the production of these sequences is often expensive in terms of time and resources. Typically, decisions regarding their form and composition are made on an intuitive and a subjective basis. Investigating the instructional effectiveness of these sequences provides educators and programme producers with a more rational foundation upon which to base these decisions.

The Theoretical Context of the Problem

Educational technology provides a framework within which this problem can be considered. Educational technology has been defined by the United Kingdom's Council for Educational Technology (Percival & Ellington p 19, 1984) as

"the development, application and evaluation of systems, techniques and aids to improve the process of human learning "

Thus the primary function of educational technology is seen as improving the efficiency of the process of learning. The theoretical sources upon which this improvement may be based come from a diversity of sciences: psychology, sociology, communications and systems analysis, all contribute to the science of educational technology. It is within this overall framework that the interaction of the variables associated with learning from television can be examined.

The problem involved a number of interacting elements (1) the instructional situation and the type of learning

involved, (2) the cognitive structures and processes that take place within the individual during learning, and (3) the nature of the television presentation used to stimulate the learning. The corresponding theoretical basis for each of these interacting elements are (1) instructional design theories, (2) theories of learning, and (3) media theories. By considering each of these in turn, a theoretical foundation for the research problem can be established.

The Scope of the Study

This study will begin by considering instructional design theories with particular emphases on the teaching of concepts and rules. Learning from television will be explored in the context of information processing theories of learning. The characteristics of television and its unique attributes for learning will then be outlined briefly. These will provide a theoretical framework for interpreting related research and provide a rationale for the nature and design of the empirical part of this study. The research question will then be investigated in a specific experiment. The study will conclude with a re-examination of the theories in the light of the experimental results.

Chapter Two - Review of Related Theories and Research

Instructional Design

Instructional theories are concerned with improving the effectiveness of teaching and instruction Brunner (1964) comments that whereas learning theories are mainly descriptive and explanatory, instructional theories are predominantly prescriptive Bovy (1981, p 205) describes instructional development research as based heavily on either logical or psychological premises, she comments

"Variations of the instructional systems approach emphasize an orderly analysis of learner goals and desired outcomes as a basis for the development of internally consistent objectives, task hierarchies and instructional sequences that utilize a logical development framework

In contrast, psychological approaches attempt to formulate instructional methods based on learning theory and include such diverse approaches such as programmed instruction based on behaviourist stimulus-response psychology, modeling based on social learning theory, or advance organizers based on cognitive theory "

Not all instructional design developments fit neatly into either of these classes but the distinction is useful The question of how we learn visual concepts and rules from television will first be considered in terms of its logical instructional context before the relevant psychological aspects of the problem will be considered

Types of Learning

A statement of objectives and an analysis of the learning tasks are common features of instructional design theories (for example, Gagné and Briggs, 1974, Romiszowski, 1974, and Anderson, 1976) Bloom (1956), identified three general domains of learning (1) cognitive, (2) affective, and (3) psychomotor Gagné (1985) describes learning in terms of human capabilities, he expands the taxonomy of Bloom and defines five categories of human capability (1) cognitive strategies, (2) attitudes, (3) motor skills, (4) procedural knowledge or intellectual skills, and (5) declarative knowledge or verbal information

Gagné and Briggs (1979) also identify different types of intellectual skills discriminations, concrete concepts, rules or principles, and problem solving This list is hierarchical and in general, attainment at the lower levels is a prerequisite to the higher levels of learning This classification of learning types, is necessary for the correct formulation of questions regarding media effectiveness Successful strategies and procedures that facilitate one type of learning may not necessarily facilitate another

The types of learning that are relevant for this research problem are concept learning and rule learning The term principle learning is synonymous with rule learning and the former term is often used in a science context (Gagné,1966)

Although many definitions of concept learning exist, (for example, Berlyne, 1965, Kendler, 1964, and Hunt, 1962) most

definitions share some general properties, Gagné (1966, p 83) judged these to be

"(1) A concept is an inferred mental process

(2) The learning of a concept requires discrimination of stimulus objects (distinguishing "positive" and "negative" instances)

(3) The performance which shows that a concept has been learned consists of the learner being able to place an object in a class "

Gagné & Briggs (1979) identify two types of concepts concrete concepts, and defined concepts. A concrete concept is a capability that makes it possible for an individual to identify an object property or an object attribute (for example, colour or shape). The human performance which is required to show that this capability has been attained is that of *recognition* of a concrete object. Concrete concepts can be learned through direct encounters with specific concrete examples of the concept (for example, 'door', 'triangle'). Defined concepts are learned by means of a classifying rule or definition, they cannot be learned through concrete examples alone. Examples of defined concepts are 'liberty', 'patriotism' and 'family'. The performance required to show attainment of a defined concept is that of being able to *demonstrate* the meaning of some particular class of objects, events or relations.

A rule or principle is the human capability of being able to respond to a class of situations with a class of performances that represents a relationship (Gagné, 1985)

The criterion performance for principle learning is that of demonstrating the principle in a variety of different situations. For example, the principle of work in physics is a relationship of the form "work= force x distance", demonstrating this requires not just a verbal or mathematical knowledge of the formula but also the ability to apply the it to a variety of practical situations

Concept and Principle Learning

The results of extensive research into the effectiveness of different approaches to concept teaching are in general agreement. A range of instructional guidelines have been proposed (Gagné, 1985, Tennyson & Park, 1980). Presenting a definition of the concept in terms of its critical attributes has been shown to be an effective first step in the instructional process (Carroll, 1964, Klausmeier, 1976, Merrill & Tennyson, 1977). Providing a set of examples and non-examples has also been shown to significantly contribute to teaching effectiveness (Tennyson, 1973). Instructional effectiveness is further increased if examples of the concept to be learned differ widely in terms of non-critical attributes. For instance, presenting two examples of the concept 'triangle' that differ greatly in terms of size. When presenting non-examples alongside examples instructional effectiveness is increased if these differ in the minimum number of critical attributes at a time (Klausmeier, Ghatala & Frayer, 1974, Markle & Tiemann, 1969, Merrill & Tennyson, 1977). Research also indicates that examples should be

presented in order of increasing divergency and difficulty (Tennyson & Park, 1980)

The teaching of rules is governed by many of the same guidelines as teaching concepts (Gagné & Briggs, 1979) Obviously knowledge of component concepts is a prerequisite to rule learning A demonstration of various applications of the concepts is recommended by Gagné & Briggs (1979)

The Events of Instruction

Gagné & Briggs (1979) define instruction as a set of events external to the learner which are designed to support the internal processes of learning A learning event involves several internal processes, each of which may be influenced by the external factors of instruction Gagné & Briggs's (1979) external events of instruction are (1) gaining attention, (2) informing the learner of the objective, (3) stimulating recall of prerequisite learnings, (4) presenting the distinctive stimulus features, (5) providing "learner guidance", (6) eliciting the performance, (7) providing feedback about performance correctness, (8) assessing the performance, and (9) enhancing retention and transfer Gagné (1985) relates these to nine phases of learning which describe the cognitive processes involved, they are (1) attending, (2) expectancy (activation of executive control processes), (3) retrieval (of relevant information) to working memory, (4) selective perception of stimulus features, (5) semantic encoding, (6) retrieval and responding, (7) reinforcement, (8) cueing retrieval, and (9) generalizability

The information processing theories of learning (to be reviewed later) focus on tracing and describing these sequences of mental operations

How television functions in relation to these events of instruction and phases of learning is an important question. It is obvious that *attracting attention* and *assessing the performance* require two very different media capabilities. Reiser and Gagné (1982), point out, that some instructional events are impossible for some media, while others are inherently easier. For example, television can present certain stimulus material in a unique way, however, it cannot easily provide feedback about performance correctness.

Theories of Learning

Overview

The objective of this study was to investigate the instructional effectiveness of different approaches to teaching concepts and principles through television. Learning theories can provide working models of the processes and structures involved in the acquisition of knowledge (Bell-Gredler, 1986). How these processes and structures function, specifically in relation to learning from television, is an important aspect of the research question.

Two key orientations to learning theory are the behaviourist and the cognitive approaches. Behaviourists have tended to emphasize the relationship between an external change in performance and an applied stimulus.

situation Cognitive psychology, on the other hand emphasizes how the learner processes new information and how knowledge is perceived and memorised within the individual (Bower & Hilgard, 1981, Estes, 1978). Behaviourists, concentrate on conditions external to the learner Whereas, cognitivists focus considerable attention on mental processes and how these relate to external conditions

Behavioural psychology is sometimes referred to as the stimulus-response approach Thorndyke's Theory of Connections, Pavlov's Classical Conditioning and Skinner's Operant Conditioning are among its key theories Many significant concepts have been derived from behavioural psychology, including retention, transfer and the use of learner performances (Richey, 1986) However, their concentration on overt behaviour has limited their contribution to instructional design and the creation of effective instructional television

Current cognitive theories of learning involve such structures as sensory registers, short-term and long-term memory and the processes involved in the perception, storage and retrieval of information Much of the recent research in instructional media reflects a cognitive, information processing perspective, (for example, Salomon, 1984, 1974, Beck, 1984) Guidelines for instructional message design have been drawn to a large extent from recent conceptions of human memory and perception (for example, Fleming and Levie, 1978, Tennyson and Breuer, 1984, Kozma, 1986)

The Information Processing Model of Learning

Cognitive psychology is concerned with how we cognise or gain knowledge about the world. Most cognitive psychologists would follow the information processing (IP) approach to learning (Bower & Hilgard, 1981). This is not a simple unified theory, rather it represents the commonality of ideas developed from a number of disparate sources. The IP model explains learning in the following way. *Inputs* (the IP version of external stimuli) are perceived via the *sensory receptors*, this process of perception may involve *attention, recognition and classification* procedures. If the information is registered it may be transferred for storage, in a temporary fashion, to the *short-term memory* (STM). Another process called *semantic coding* may then take place, where the information enters the more organised *long-term memory* (LTM) in a meaningful form (Bower and Hilgard, 1981). Gagné's (1985) events of instruction provide the link between these internal mechanisms and processes, and the design of teaching sequences.

Perception

As perception is the first stage in the process of cognition it is critically important in any learning situation. Learning is limited by what the learner perceives and what is given attention. Neimark and Estes's (1967) stimulus sampling theory suggests that a person will not respond to all available stimuli but only to a sample of those presented. Learners are highly selective and only specific kinds of

stimuli can take effect Salomon (1979) describes television and film as dense media, capable of presenting information in a variety of symbolic forms An educational television programme may present a learner with a very large number of stimulus elements simultaneously, and not all of these will be attended to A teacher may show a travel programme to children, without some form of guidance each child may notice different aspects of a scene, if a particular building is featured, some will notice the windows, others the overall shape and still others will only notice the colour Different children will sample the information presented differently (Travers, 1982)

"Attention" refers to activities related to the selection of information from some particular aspect of environment "Preattention" is a state of readiness for attention We can give attention to only a small part of the environment at any one time Sensitivity is not invariant across the visual field a small fraction of the area of vision, the foveal area, is highly sensitive, while the rest of the visual field, the peripheral area, is less sensitive The preattentive aspect of vision, involves the peripheral- wide angled, field and provides the person with a global, holistic viewpoint The attentive aspect of vision is foveal, narrow angled and specific Levie and Lentz (1982) have shown that pictures without attention-directing prompts may be scanned only superficially and processed at a very shallow level

Berlyne (1970) and Fleming & Lévie (1978) maintain that changes in brightness and movement in the preattentive

visual field will stimulate visual attention, changes in volume, pitch or direction will stimulate audio attention. Producers of educational television can use movement, flashing arrows and other devices to draw attention to relevant stimuli.

The nature of the internal processes of perception and attention is particularly significant for three of Gagné's external events of instruction: gaining attention, presenting distinctive stimulus features, and presenting learner guidance. Visual concepts and principles presented through television may present the learner with a very dense array of external stimuli. Production techniques which highlight and draw attention to the distinctive and relevant features of visual sequences will facilitate perception and attention.

An important aspect of the perceptual process is the way perception is organised. A chess grandmaster will very quickly perceive the situation of play on being confronted with a novel and complex board setting (Simon, 1978). Part of this skill is the quick recognition of pattern information. The (Simon, 1978) concept of "production" may help explain this. Information processing theorists describe a production as an individualized strategic subroutine involving a condition component (a set of tests to be applied), and an action component.

The organisation of perception may also be conceived in terms of the notion of schema, that is, that behaviour, including perceptual behaviour, is organised in terms of

chunks or frames (Travers, 1982) There is a strong tendency to construct relationships, groupings, objects, events, words and people The individual will impose these organizations upon stimuli where they are not given (Eysenck, 1984)

Being one of the earliest stages of cognition, perception has an important influence on the others Reciprocally the other cognitive processes influence how we perceive Identification procedures involving recognition greatly affect how we will attend to selected aspects of incoming information

There is a dynamic relationship between perception and memory, and this helps explain why perception is so strongly influenced by expectations What we perceive is related to what we expect to perceive, and what we expect to perceive is determined by what we remember Neisser (1976, pp 20-21) explains the relationship between expectations and attention in terms of anticipatory schemata that prepare the perceiver to accept certain kinds of information rather than others and thus control the activity of looking

"Because we can see only what we know how to look for, it is these schemata (together with the information actually available) that determine what will be perceived The outcome of the explorations- the information picked up- modifies the original schema Thus modified it directs further exploration and becomes ready for more information "

This description of the interactive nature of attention, with both features of the external environment and the

learners anticipatory schemata involved, has implications for the design of instructional television. Television sequences that present the learner with highly organized and structured visual stimuli will facilitate meaningful perception and identification. When presented with such a display, the learner can compare aspects of it with existing cognitive schemata and immediately interpret it. This interpretation will itself modify the existing schemata. Alternatively, visual sequences that are too complex or unstructured make it difficult for the learner to match aspects of the display to existing schemata.

The use of movement or animation in television sequences designed to teach visual concepts, may help the viewer organize and assimilate the material. If the movement is too complex it will be difficult to match to the viewer's existing cognitive schemata and learning will not be facilitated. Bovy (1981) proposes that instructional methods can activate learner attention by either manipulating the external features of the instructional display or by manipulating the cognitive schemata of the learner. Salomon's (1979) studies on the interaction between the television operation of zooming and the cognitive operation of cue-attendance, support this position.

Memory

Adams (1980) reviewed the experimental evidence pointing to a number of distinct memory systems. The consensus centres on two memory systems the short-term

memory (STM) which is of limited capacity and receives the attended-to information from the sensory receptors and the long-term memory (LTM) which is a more permanent system with information stored in a highly processed form (Klatzky, 1982)

The STM operates by coding, this involves imposing a temporary name or internal representation on the stimulus element. The form of this representation may be different from that of the original object. For example, the visual presentation of the letter L in a word list may be coded as the vocal name "ell". Bower and Hilgard (1981) speculate that the effect of this vocal naming is to convert the visual stimulus into an internally articulate form. The opposite may also take place, a vocal stimulus may be recoded into visual form. This internal representation of the target item will influence the type of materials that will interfere with it (vocal or visual) and the kinds of confusions or errors that people will make when they misremember the item.

When the to-be-remembered item enters the STM in coded form, it will enter one of the limited number of "rehearsal slots" available and, over a period of time, three outcomes are possible. The item may be replaced by a new arrival before any further coding takes place. This assumes that forgetting in the STM is simply the displacement of an item by another. The second possible outcome is that the information will be further processed and will enter the LTM adding to the learners organised conception of the world. The final

possibility is that the item will be rehearsed, brought back into and maintained in the system

The organisation of information is crucial for the effective transfer of material from the STM to the LTM. When presented with a random list of words to remember, an individual will impose groupings on the material during recall (Tulving, 1967). Bower et al (1969) showed that structural organization facilitates the retention and free recall of categorized word lists.

Memory Structures

Several kinds of memory structures have been proposed by cognitive psychologists and much controversy surrounds their exact nature and form. Two key orientations are the dual-code theories and the unitary code theories (Klatzky, 1980). The dual-code theory proposes that memory structures for verbal and for pictorial information are different. One of the principle advocates of this approach is Paivio (1971), who proposes a dual-code or dual-systems structure for representing information. He distinguishes between the verbal system, which is used for knowledge that can usually be expressed in words, and the imaginal system which is used for processing and storing nonverbal information in the form of mental images. Studies of mental rotation by Shepard and Metzler (1971) and Shepard and Cooper (1973) and image scanning by Kosslyn, Ball, and Reiser (1982) support the view that people can store and manipulate

mental images in a form that is analogous to physical pictures

Alternatively, unitary theories propose that visual and nonvisual information is represented and stored in the same way. Many theorists (Anderson and Bower, 1973, Kintsch, 1972) take the view that memory structures are organized by means of networks of propositions, these propositions consist of concepts and relations between concepts which are connected by means of associations. Pylshyn (1979) and Palmer (1978) suggest that mental images are stored as propositions that are similar in form to those of verbal information.

Anderson (1978), attempting to reconcile the two approaches to visual coding, maintains that the propositional and imagery models are functionally equivalent and that both positions can account for many empirical outcomes. He argues that there may be advantages to retaining both views, in the same way as the particle and wave theories of light are employed in physics.

An important proposal concerning the gross structure of the long-term memory comes from Tulving (1972). He suggests that LTM is organized at two different levels: the *episodic* and the *semantic* memory. These systems differ from each other

"(i) in terms of the nature of stored information (ii) autobiographical versus cognitive reference, (iii) and the conditions and consequences of retrieval", (Tulving 1972, P 385)

The autobiographical episodic memory records events in temporal order and the associated sensory attributes along with it. A person may remember a childhood episode or a scene from a film, in this fashion. Semantic memory is the memory necessary for language and other cognitive skills, again quoting Tulving (1972 P 386) "*Semantic memory does not register perceptible properties of input signals*". The evidence for two separate systems is not conclusive (Bower and Hilgard, 1981, Travers, 1982). However, the distinction between the two types of stored information is important. An episodic memory system would imply that information is stored along with a variety of personal feelings experienced at the time of learning. Successful retrieval cues will relate to events and experiences rather than logical association.

Gagné and White (1978) review the research on the relationships between memory structures and learning outcomes. They identify four kinds of organized memory structures from the various theories: (1) networks of propositions, (2) intellectual skills, (3) images, and (4) episodes. They stress the importance of links and relationships between the different memory structures. They urge that educational media, including television, should be examined in the context of the memory structures they generate.

Information may be stored in more than one form. It has already been mentioned that the coding process for the representation of the letter L may involve the vocal element "ell". In the same way, part of a picture may be stored in

lexical form (D'Agostino, O'Neill, and Paivio, 1977) Deep processing involves the recoding of materials at deeper levels, say, when the semantic meaning is extracted from pictures, (Craik and Lockhart, 1972) Craik and Lockhart, propose that this depth of processing is the significant factor in retention, the deeper the level of processing the more permanent the trace

Television has often been cited as a medium which may inhibit "deeper" processing (Salomon, 1984), the pictoriality, "crowdedness" pace and variability would seem only to allow for global holistic recognition and not deep semantic processing The concept of (AIME), the amount of invested mental effort (Salomon, 1984) has been developed as a measure of depth of processing Salomon found that as television was perceived as a realistic and "easy" medium by children then AIME and consequently learning was less than that for print

Retrieval

The relationship between the long-term and short-term memory is a dynamic one, with relevant information retrieved from the LTM, being used to organize the incoming elements The retrieval processes are the least well studied aspect of memory but there is general agreement that retrieval from memory calls for specific and relevant cues (Travers, 1982)

In the encoding specificity orientation the ability to recall information is a direct function of relationship between the encoding conditions and the retrieval cue

(Tulving and Thompson , 1973) Retrieval of information relies upon the appropriate external cue to match the stored memory trace An appropriate external cue perhaps being one that was stored during learning Recognition and recall are therefore strongly dependent on the context in which the original learning took place

Spatial Ability

It would seem to be appropriate that the moving images presented through instructional television should be studied in the context of mental imagery The mental skills available to the learner (in particular spatial-ability) should affect the learning outcomes from instructional television sequences Referring to a Salomon (1972) supplantation experiment, Allen (1975, p148) states

" these studies seem to underline the greater representational capabilities of the motion picture in that it can show the transformations that occur in a process and present a model that the learner can imitate and internalize as a substitute for his own deficient mental processing skills "

Apart from the nature of image representation within memory structures, the properties of these "images" and how they function in relation to certain types of learning have been the subject of much debate (Block, 1981) Research has established however, that internally generated imagery can be rotated, manipulated and transformed and that people can and do manipulate mental images to answer questions (Kosslyn, 1980)

Spatial-ability refers to the ability of an individual to generate and manipulate mental images. Many studies have shown that spatial-ability is positively correlated to mathematical, scientific and technical competence (Smith, 1964, Eastman & Carey, 1975 and Guay & Mac Daniel, 1977). The role of mental imagery in concept learning and problem solving has also been outlined (Katz & Pavio, 1975).

It is not possible to directly detect the occurrence of internal events such as mental representations. Studying the properties of mental images presents experimental psychologists with great difficulties in methodology and many of the techniques depend on second order detection. Externally observable events such as vocalizations and key presses are usually used, with these being timed and recorded. Psychologists such as Sternberg (1966), Posner & Mitchell (1969) and Shepard & Metzler (1971) refined these chronometric techniques and numerous studies have shown the extent of human abilities in relation to image generation and manipulation.

Mental Rotation

The ability to rotate mental representations is an important imagery ability. It is possible to rotate and manipulate an object in the "mind's eye". For example a person wishing to rearrange suitcases to fit in the boot of a car might imagine the different possible configurations before physically performing the task. In an experiment to measure the rate of rotation, Shepard & Metzler (1971) presented

subjects with abstract computer generated images which after rotation would or would not, match a target image. They found that the greater the angular disparity, the longer it took for the subjects to give the correct answer. From these findings, Shepard & Metzler concluded that the cognitive operations that can be performed on images are analogous to the operations involved when a physical stimulus is viewed. The subjects were rotating the mental images at a constant rate and they almost universally reported that they did the task by watching their internal images rotating.

Mental Transformations

Many studies on other mental transformations produced similar results. Shepard & Feng (1972), and Cooper & Podgorny (1976) studied how people perform three-dimensional and two-dimensional rotation tasks and paper folding tasks respectively. Generalizing about the results of these and similar studies Shepard and Cooper (1982, p 10) comment

" the patterns of latencies of overt responses mediated by such covert mental operations bear a remarkably consistent and orderly relation to the complexities and extents of the spatial transformations corresponding to those internal operations "

In all these tasks, people report "looking at" the mental image as it rotates or transforms. Shepard and Cooper conclude that the way these operations are carried out is directly analogous to the way such operations would be performed on physical stimuli. It was also clear that some

sort of inspection of the images takes place after the manipulative processes have been performed and that the real computational work is being done by the cognitive operations that manipulate the image and not by some other perhaps nonvisual process, (Metzler & Shepard, 1982)

Perception and Imagery

The nature of the relationship and interaction between imagery and visual perception has been studied (for example, Segal 1972) Wicker (1978) suggests that if imaginal coding processes occur in parallel with or in sequence with, other perceptual processes, then the implications of this for learning and instruction need to be explored The Broadbent (1958) information processing model of human visual cognition indicates that the cognitive system has a limited capacity for assimilating incoming stimuli Self generated imagery may occupy the same short-term memory space as perceived visuals Where images do not contribute in a meaningful way to content, they may further limit the capacity of the system Experiments by Brooks (1967), Atwood (1971) and Bower (1970) showed that visual perceptual interference tasks can hinder visual recall and that auditory-interference tasks (Atwood) and tactile-interference tasks (Bower) were less of a hindrance These studies imply that learners use the same mechanisms for processing their mental imagery as they do for visual perceptual processing

The Function of Images

The functional properties of mental images have important implications for learning and teaching. Kosslyn (1985) identifies different ways in which images can be used in learning. They may be used as an aid to memory, or they may function as a tool in practicing a physical activity without actually doing it, and they may function as an aid to reasoning. The effectiveness of imaginal mediators in mnemonic systems and verbal learning has been established (Paivio, 1971, Atkinson, 1975). Other studies have shown that imagery can be used effectively to facilitate science rule learning (McIntosh, 1986) and that there is a correlation between spatial ability and problem solving skills in chemistry (Carter et al 1987).

Media Theories

The Characteristics of Television

An important question in examining the instructional effectiveness of different media is in what way does learning from one medium differ from another. The answer to this question will be influenced by the instructional theories adopted and the taxonomy of media attributes identified. Media can be compared on the basis of many different types of characteristics: distributional, social, control, or symbolic characteristics. In a discussion of the key attributes of television, Bates (1981) points out that the relevant type of characteristics for learning are the symbolic or audio-visual characteristics of television. MacLean (1968), Bates

(1981), and (Hutton,1984) have identified several of these key attributes of television as a medium of instruction. They include television's capability

- * to present information auditorily and visually in synchronization

- * to show movement, transitions and spatial orientations

- * to show the passage of time, stretch and compress real time, freeze a moment in time or alter completely a chronological sequence of events

- * to organize heterogeneous material into a coherent whole, enabling programme makers to create a synergy of moving pictures, dialogue, music and sound that make up an instructional television programme

Symbol Systems

Salomon (1979) maintains that the most critical attributes of a medium, where learning and cognition are concerned, are its symbol systems. A symbol system is a set of elements such as words, numbers or shapes that are inter-related within each system by systematic rules or conventions. Different categories of symbol system include *digital systems*, where meaning is conveyed in notational form (for example, text and musical notation), *analogic systems*, which are made up of continuous elements (for example, music, speech tones, voice quality) and *iconic systems* which use pictorial representation. Notational

systems convey information in a discrete and unambiguous form. In contrast, iconic systems are both syntactically and semantically "dense." They convey information with a variety of possible meanings and there is an ambiguous relationship between the symbol and its referent.

Media differ in relation to the type and the quantity of symbols they can carry. The greater the variability of the symbol system, the more levels of meaning it can potentially carry. Television can present symbol systems of many different types, for example text (digital), music (analogic) and moving pictures (iconic). Other media, for example printed text, or radio are more limited in the number of symbol systems they carry.

Salomon hypothesizes that symbol systems can facilitate learning in one of three ways, by (1) activating already existing mental skills, through providing practice in their use, (2) short-cutting difficult mental processes, through symbol systems representing knowledge in a new way, (3) supporting or modelling the mental elaborations required. The cognitive skills the potential learner influence how different symbol systems may facilitate learning.

Summary - Theoretical Approach to the Problem

The objective of this study was to determine the instructional value of explicit movement and manipulation in television sequences designed to teach concepts and

principles in science Specific guidelines for teaching concepts and principles were drawn from a review of theories of learning and instruction and associated research studies The external events of instruction and the different presentation capabilities of media were examined Television's ability to show movement and manipulation was identified as a variable which has the potential to enhance the effectiveness of an instructional presentation

Salomon's (1979) hypothesis that the symbol systems of media could interact with the cognitive processes that take place within the individual during learning was used to highlight the link between the external and internal events of instruction Information processing theories were used to describe of the processes of attention, perception, memory and retrieval that take place during learning

The information processing models proposed that

*Information is processed in sequential stages, and each stage occurs within a particular structure in the memory system

*The sensory registers receive a vast array of information from the external environment much of which is lost and not processed any further

*The short-term or working memory is responsible for encoding the information into a meaningful form and maintaining it until it can be further processed for more permanent storage in the long-term memory

*The capacity of the short-term memory is limited and information that is not passed to the long-term memory is replaced by new inputs from the sensory registers after a period of time

These descriptions of the internal information processing mechanisms have implications for the external events of instruction and the design of instructional television

*To gain the learner's attention, devices involving changes in brightness, movement and sound intensity will stimulate attention. For example, using a rapidly moving sequence at the beginning of a programme, a flashing arrow pointing to a particular element on the screen, or a change in sound level during a particular process

*To inform the learner of the objectives, orienting activities such as the use of advance organisers (Ausubel, 1968) can be used. These may be in the form of programme titles, or motivating sequences. Gagné suggests that these relate to activating the learners executive control processes. As television is perceived as an "easy" medium effective cueing of cognitive strategies is important to maximise the amount of mental effort expended (Salomon, 1984)

*To stimulate recall of prerequisite learning, the use of organizational structures that are easily recognisable and that relate to the learners existing cognitive schema is recommended

*When presenting the stimulus material the information processing theories suggest that simple presentations, with the target stimulus elements presented in isolation or with orienting devices to draw attention to them, will be effective. Instructional television sequences should avoid unnecessary effects and ornamentation as these additional stimuli may distract from the relevant content. Material organised both visually and aurally into logical frames or chunks will facilitate easy perception and memory. The limited quantity and duration of material that can be handled by the short-term memory suggests that the pacing of an educational television is important. Adequate time for the processing of visual and auditory information is needed. Presenting parallel and complementing audio and visual stimuli, say, pictorial information accompanied by either textual or vocal reinforcement provides the learner with a number of coding options. This should facilitate rehearsal in a variety of coded forms and thereby increase the chances of transfer to long-term memory and retention (Beck, 1984)

*When providing learner guidance, Salomon (1979) suggests that media can model the appropriate skills necessary for cognitive processing. Visual media are particularly useful for providing learner guidance, they can influence the semantic encoding process by helping learners establish mental images which in turn are capable of enhancing retention (Reiser and Gagne, 1982). The use of different stimulus forms for example, reinforcing pictures

with text may suggest certain appropriate recoding possibilities

Apart from the different memory structures some theories pointed to different types of information that can be processed. Pavio's (1971) theory deals with the processes that are involved in the recognition and interpretation of pictures. According to this theory, human information processing involves two systems, a verbal symbolic system which is specialised in processing temporal sequenced information and an imaginal symbolic system (or iconic mode) which is specialised for processing spatial simultaneous information (i.e. in pictorial form). These systems operate independent of one another but they do interact and information may be transferred between the verbal and the imaginal codes. In the iconic mode the short-term memory space may be occupied by two forms of representations, perceptual representations (pictures) and mental representations (imagery) (Clark, 1978). Perceptual representations come from external sources via the sensory registers, mental imagery on the other hand originates from internal sources.

Spatial ability was identified as a significant cognitive skill. It was shown that individuals have the ability to generate internal representations that are similar in form to perceived images and that these representations can be used to answer questions and to reason in certain ways. It was also shown that imagery may occupy the same short-term memory space as perceived visuals and it could therefore

interfere with learning when it is not relevant to the task in hand. Similarly, learning that uses imagery as a tool in reasoning or as an aid to memory can be hindered by irrelevant visual perception.

Review of Related Research

Cross Media Comparisons

Early studies of the effectiveness of educational television concentrated on comparisons between television and other media (reported in Schramm, 1977) and comparisons between television and traditional classroom instruction (Chu and Schramm, 1967). The poor quality of the experimental design of many of these studies was highlighted by Stickell (1963). He analysed 250 of these comparison studies and found that only 10 were able to satisfy basic design criteria and thereby provide results that were interpretable. Most of the studies that did provide interpretable results showed no significant difference between television instruction and other forms of instruction (Ackerman, 1977).

The theoretical formulation of these early studies has been criticized by numerous commentators. Schramm (1977), Levie and Dickie (1972) and Salomon (1979) argue for the study of inherent media characteristics rather than intermedia comparisons. Identifying a medium's individual attributes and characteristics and examining their

significance in relation to learning became the goal of later research

From the beginning of the 1960s, research seeking to evaluate the instructional potential of educational television, tended to focus on a multiple-variable conceptualisation of the problem (Williams and Van Wart, 1974). The complex interaction of educational television variables presented enormous problems for investigators. Many reviews of educational television research (for example, Schramm, 1972, Coldevin, 1981) highlight the educational significance of seemingly minute details of programme design. However the absence of a theory and the "one-shot" nature of many of these studies limited their value, as Goldevin (1981, p 96) comments

" experimental research should continue to work towards theory building through the replication of studies in a variety of settings. The one-shot study stands little chance of providing a substantial contribution even though it may be valid per se "

Much of the research into the great number and variety of variables associated with educational television has contributed little by way of universally applicable results (Salomon, 1979). Identifying and manipulating individual attributes and production variables such as the use of colour, the nature of the sound-track or the background composition, provides only isolated and non-generalizable guidelines for practitioners. Many of the conclusions are content dependant. For example, studies on the effectiveness of colour versus

black and white presentations show that colour is superior only when it is used as an aid for discrimination or where colour is itself part of the learning task (Kanner and Rosenstein, 1960)

Developments in cognitive psychology and new approaches to instruction have given rise to more specific and useful research questions. When educational television was examined in the context of the attributes of the medium and their interaction with the task, instructional situation and learner characteristics, more useful results were obtained (Levie and Dickie, 1972). The research question shifted from "can television teach" to "how does television teach"?

Trait Treatment Interactions

One of the most important developments for media research was the re-evaluation of the significance of individual differences and the emergence of trait treatment interaction research (Cronbach & Snow, 1977). This approach stemmed from an increasing realisation of the importance of differences in cognitive structure and personality traits between individuals. The notion of the 'average learner' was found to be too simplistic and researchers began to look on individual differences not as unwanted noise but as significant variables in the experimental design. The instructional situation was regarded as a complex system of interacting elements and learning was interpreted as the result of interactions between particular features of the

learning environment and specific characteristics of the individual learner (Heidt, 1976)

In general, the terms "Trait Treatment Interaction" and "Aptitude Treatment Interaction" are used synonymously (Dwyer, 1978 & Heidt, 1976) An aptitude treatment interaction exists when, as a result of a given treatment, individuals at one end of an aptitude variable perform at one level of a criterion measure and the individuals at the other end perform at a significantly different level and the reverse holds true for a second treatment (Parkhurst, 1975) Heidt (1976, pp81-82) outlines some of the characteristics of trait treatment Interactions

" - Personality traits and environmental factors are interactively related

-Behaviour, in general, and learning results in particular, can only be explained by taking this interactive relation into consideration

-The behaviour of individuals can be deliberately influenced through a manipulation of environmental factors

-Different personality traits require different environment factors, if the same behaviour or the same learning results are to be achieved

-The personality traits under consideration must at least have a certain degree of stability and generality

-As different cognitive processes, in particular internal information selection and processing operations, are held responsible for differences in learning results, the process feature is emphasised as against the product aspect "

Clark (1975), Di Vesta (1975) and Cronbach & Snow (1977) suggest that the trait-by-treatment conception provides the most useful framework for the design and interpretation of experimental studies on media effectiveness. They suggest that it is possible to identify aptitude and personality variables that will interact with specific instructional treatment variables.

When considering media as possible treatment variables, Salomon (1979) suggests that they should be defined in terms of their unique presentation attributes which fulfil unique psychological functions. The attributes of a medium are its capabilities to show objects in motion, in colour, in three dimensions or, to provide printed or spoken words, simultaneous visual and auditory stimuli, and so on (Levie and Dickie, 1972). The ability to show objects and processes in motion is often cited as one of television's most important attributes and Ackerman (1977 p 159) points to the need for further research on this variable. He also states

"If cognitive theorists are correct (and research suggests they are), human thought processes must surely involve dynamic transformations of information. How can the attribute of motion (which represents dynamic transformations of visual stimuli) be used to influence the dynamic transformations of thought?"

The ability to show motion and the psychological function of mental manipulation are possible treatment and aptitude variables. Spatial-ability, as a measure of an individual's capacity to manipulate mental images, and the degree to which visual learning processes are presented dynamically

through television, should give rise to an aptitude-by-treatment interaction

Trait Treatment Interaction Research

Reviews of trait treatment interaction research (Heidt, 1977, Cronbach and Snow, 1977 and Dwyer, 1978) have shown that the number of significant interactions is small and the overall results are disappointing. Heidt (1977, p13) comments

"Only very few significant interactions have been experimentally proved to date. Results are not only contradictory, but even positive studies, i.e., those that detect a ATI effect, are so inconsistent that they cannot be summarized in any general way."

The work of Salomon (1974) on the cultivation of mental skills through the use of filmic and television coding elements is significant. He hypothesized that specific filmic coding elements could be made to cultivate the mastery of specific mental skills. Transformational coding elements such as the zoom, the 'laying out' of objects and the rotation of objects were used.

Salomon (1974) proposed that zooming would overtly model the process of singling out objects or details from visually rich displays. Participants were pretested and post-tested on cue-attendance skills. There were three treatment conditions: (1) *modeling*, where the camera zoomed in and out of details from paintings, (2) *short-circuiting*, where slides showing first the wide view and then the details were shown,

and (3) the *activation* condition which showed only a wide view of the paintings. The results showed that the coding elements used together with the task requirement could be made to affect the mastery of the cue-attendance skill. The study revealed a strong and significant aptitude treatment interaction between initial cue-attendance scores and the conditions of activation and modelling.

In another experiment Salomon (1979) tested the relationship between the verbal ability of students and the effectiveness of television modelling for the cultivating visual skills. The gains in visual ability were measured by a paper folding pretest and post-test. With visual skill acquisition as the dependent variable he found a strong and significant aptitude treatment interaction between the film operation of transforming visualized objects into two-dimensional plans and the learner's verbal ability.

Salomon (1977) also investigated the different effects of television and film coding elements on knowledge acquisition. He tested the proposition that the coding elements would vary with respect to the amount of mental re-coding (translation from external to internal representation) they require relative to a person's abilities. Salomon used five different treatments of the same television film: (1) *fragmentation of space*, (2) *logical gaps*, (3) *close-ups*, (4) *long-shots*, and (5) *simple*. Each of these treatments, except the last, emphasised a different coding element and hence, required different degrees of mental elaboration for re-coding. Salomon pre-tested the participants with a battery of six

tests to measure specific mental skills. The skills measured were those corresponding to the manipulated coding elements. The results showed that the different coding elements did call upon different mental skills and that the levels and types of skill measured in the pre-test correlated with the learners ability to cope with the different treatments. For example, the visual memory pretest was a good predictor of performance on the logical gaps version of the treatment.

A study by Carrier and Clark (1978) explored the relationships among mode of presentation (verbal versus spatial), the level of explicitness of the presentation and the students verbal and spatial aptitude (High Verbal Low Spatial vs. Low Verbal High Spatial). Explicitness was defined as the use of instructional strategies that model a particular series of behaviours to be followed in solving a particular class of problems. The criterion measure was the students ability to work out the area and volume of two and three dimensional objects. Evidence was found of an interaction between the spatial and verbal versions of the treatment and the aptitude measure. However, no interaction was found for the level of explicitness variable, the more explicit treatments were superior regardless of aptitude.

Carrier and Clark (1978) suggest that the absence of an interaction for the level of explicitness variable could be due to an erroneous conceptualisation of the relationship between the skills assessed by the individual difference measures and those required by the task. Cronbach and Snow (1977) also criticize many previous similar ATI studies for this failure.

Studies investigating the relationship between spatial ability and spatially oriented treatments have been inconclusive and have failed to show the predicted interactions (Cronbach & Snow 1977). Many of these studies (for example, Behr, 1970, Bracht, 1969 and Allen & Daehling, 1968) hypothesized that high spatial ability participants would automatically benefit from treatments involving diagrams, charts or other visual devices, as against highly verbal treatments. This assumption may not be true, as Cronbach and Snow (1977, p 505) point out

A training programme that uses diagrams or symbols is not necessarily spatial. Spatial abilities are probably required if, in the course of training, the persons must visualize changes in shape under rotation and other operations. No such treatments have been clearly specified.

Allen (1975) explored the relationship between intellectual abilities and instructional media design, he used the general term *mental abilities* to refer to the attentional, perceptual, processing and analytic skills of an individual. In an *a posteriori* analysis of studies by Gagné and Gropper (1965) and Allen et al (1970) he found that, for learning of concrete concepts and facts, higher mental ability students will benefit more than lower mental ability students from visually complex motion pictures as against verbal presentations. However, other studies by Allen, Filep and Cooney (1967) and by Koran, Snow and McDonald (1971) found that, for learning of more abstract content, lower mental

ability students seemed to profit more from the television/motion presentation

These results highlight the complexity of the problem highly explicit information-rich television presentations may place excessive information processing demands on low ability students and thereby hinder them. Alternatively, such presentations may model or supplant the difficult mental processes required for learning, and thereby facilitate the low ability students

Learning from Pictures

The processes of perception and memory for pictures have been the subject of extensive research and a variety of theories have been proposed to explain how we perceive and memorise pictorial information (see Paivio, 1971, Turvey, 1978). The information processing approach to human visual cognition (Seymour, 1979, Bell-Gredler, 1986) offers a working model for understanding the structures and processes involved in learning from pictures

Research on how people learn from still pictures can give important insights into learning from television. Studies investigating the degree of realism, the use of colour, the use of text and other variables have relevance for all visual learning. A brief review of the research on learning from pictures is presented here

Many studies have compared learning from illustrated text with learning from text alone. Levie and Lentz (1982) provide an extensive review of 55 experiments on various combinations of illustrated and non-illustrated text. They conclude that learning relevant information was better with illustrated text than with text alone in 95% of the experimental comparisons. They also found that the effectiveness of illustrations is content specific, visuals only facilitate the learning of accompanying verbal information that is highly related to the information pictured. These results would suggest that learning from television is most effective when visual illustration is accompanied by a relevant and complimentary narrative.

The work of Dwyer and his associates on learning from visuals has been responsible for many significant and applicable results. Dwyer (1972) devised a set of learning stimuli and test instruments that have served as the basis for more than 100 studies. The instructional unit consists of a 2,000-word text about the anatomy and physiology of the human heart and a set of 37 illustrations prepared in eight versions: simple line drawings, detailed shaded drawings, photographs of models of the heart, and photographs of heart specimens, each type of visual in both black and white and colour. Four dependent measures were used, a drawing test, an identification test, a terminology test and a comprehension test. Studies using these instruments have evaluated a wide range of cognitive learning factors and

presentation methods, including television. Some of their findings that relate to this study are reviewed below.

Colour and Realism

One of the most important research questions is the effectiveness of varying degrees of realism and the use of colour. Dwyer (1971) makes the point that colour is an important variable in the design and the cost of instructional materials, including television, and yet research into its effectiveness is inconclusive. Finn (1953) and Dale (1969) recommend that for instructional purposes the more realistic and lifelike the stimulus material the better it is for learning. However, Broadbent's (1958) filter theory of human perception suggests that as the number of cues presented to the learner increases a corresponding reduction in learning will take place under certain conditions. This is brought about by a filtering process that occurs within the individual. Realistic colour pictures provide the learner with a dense array of visual stimuli and may be contrasted with simple monochrome line drawings which provide less visual cues. Learners constantly filter the relevant visual cues from the totality of visual information presented to them. This theoretical formulation of visual cognition is supported by many of the studies carried out by Dwyer (1970a), who found that realism and increased detail do not always contribute to increased learning and that in some cases increased detail actually hindered learning (Dwyer, 1976).

In the case of television based visuals where the pace of presentation was fixed, Dwyer (1976) found that visuals containing less detail tended to be more effective. Visuals that were high in realism were more effective when the individual learner could control the rate of exposure as in the case of books and charts. Dwyer speculated that in the case of externally paced instruction, the more realistic presentations would be at a disadvantage to less realistic presentations since the process of identification and discrimination is time consuming. The more intricate the visual stimuli, the longer it takes for the student to identify and absorb the intended information. Realistic illustrations containing high information content are not useful as instructional aids when students are not given adequate time to scan and interact with the information. A generalisation of these findings to educational television production suggests that the pace and the amount of detail presented on screen will affect the degree of learner processing.

Dwyer (1971) also found that students across a wide age range expressed a consistent preference for complexity and variability in visualization and that people prefer to receive and interact with presentations that occur in colour.

Other studies using the Dwyer materials examined the relationship between instructional strategies and learner characteristics. Canelos et al (1980) investigated the effects of three levels of stimulus complexity for field-dependent and field-independent students (Canelos et al, 1980). The results were different for different types of

learning, in general as the learning tasks increased in difficulty field-dependents were left at an information processing disadvantage when compared to field-independents. This result implied that in any given learning situation it is likely that a specific instructional approach may be successful for only a portion of the learners present. In a follow up study, Canelos and Taylor (1981) showed that the field-dependent's deficiencies could be compensated for by training the learners in an information processing strategy (imagery peg-mnemonic memory technique). This approach may be contrasted with that of Salomon outlined above. Salomon used the zooming attribute of television to supplant and to model field independence skills, whereas Canelos and Taylor used an imagery training technique with learner control over the pace of instruction. In both cases, however, the importance of individual differences of cognitive style and the need to compensate and allow for these in instructional presentations is emphasised.

Other learner variables examined using the Dwyer visual treatments were dogmatism (ability to synthesize new visual patterns) (Berry & Dwyer, 1983), IQ level (Parkhurst & Dwyer, 1983), and reading comprehension (Dwyer & Parkhurst, 1984). In all of these studies the importance of individual differences among learners was reinforced.

Educational Television Variables

Clark (1975) points out that whereas educational psychologists are deeply committed to the development of new measures of ability, aptitude, personality and trait, these have not been complimented by parallel efforts to develop our knowledge of treatment variables Shulman (1970,p 374) comments that aptitude treatment interaction research *"will likely remain an empty phrase as long as aptitudes are measured by micrometer and environments are measured by divining rod"*

Various classification systems have been developed to cope with the great number and variety of variables associated with educational television These provide a theoretical structure for research questions and a framework whereby the educationally relevant variables can be identified, isolated and manipulated

Williams and Stanford (1977 p 89) list the variables associated with educational television research under the following categories

"Media Variables content variations, channel variations, production variations

Context Features: viewing environment, viewing frequency, associated activities

Viewer Characteristics age, sex, baseline knowledge, cultural background

Effects attention, comprehension, attitude "

This study is concerned primarily with *production variations* which come under *media variables*, the first of these categories

Goldevin (1981) gives a more specific classification system for media variables associated with educational television. He draws a distinction between *production variables*, which are characterized by definitive processes, methods or techniques of television production and *performer variables* which represent the variety of presenter characteristics. He further categorizes two types of production variables: *technical variations* and *content organisation*. Technical variations include such factors as camera angle, setting, colour vs black and white, still vs motion pictures and the use of special effects. Content organisation relates to factors such as graphic devices, opening and closing format, pacing and rhythm, cues and advance organisers.

Some of the more significant findings from these 'gross media attribute' (Clark, 1975) studies, that relate to the research problem, will be reviewed.

Camera Factors

Roshal (1959) investigated the effects of different camera angles used for different versions of films designed to teach knot tying techniques. He postulated that a subjective camera angle, that is where the camera shows the

situation as the viewer would see it while actually performing the task, should be more effective than an objective camera angle showing someone else performing the task. The subjective camera angle was more effective.

Other research, deals with the relationship between viewers attitude toward a presenter and the camera angle used to show the presenter. Baggley (1980) compared half profile and front facing shots of a presenter, he found that performers, when seen to address the camera directly were considered less reliable and expert than when seen in profile.

A number of studies have examined the potential effects of close-up, medium and long shots. Dwyer (1970b) found that provided the viewer can see clearly the stimulus to be learned, then the use of close-ups offers no significant advantage over long shots.

Setting

Most of the productive research dealing with the setting used in educational programmes examined the effects of varied backgrounds as presenter enhancement factors (Coldevin, 1981). Baggley and Duck (1974) found that the credibility of a presenter was increased when the presenter was seen against a relevant pictorial background as distinct from a plain background.

Audio Factors

Schramm (1972) reviews the results of the research activities throughout the 1940s and 50s investigating the

optimal rate of speech for audio visual or auditory instruction The results are inconclusive, factors such as the difficulty of the material and the interaction between the sound-track and the visual presentation could not easily be controlled for

Research on the effects of background music was conducted by Baggley et al (1980) They investigated students attitudes toward a presenter for programmes with opening and closing sequences using solemn or joyful music No significant difference was found other than a lower reliability rating for the presenter following the solemn music opening, however the authors caution that this may be purely a chance result

Colour

Schramm (1972) reviewed 150 experiments on instructional television and films Many of these studies investigated technical variations such as the use of colour, the angle of the camera and the nature of the sound-track The overall conclusions were that the simpler the presentation the more effective the programme He summarised that the use of colour does not seem to contribute to the teaching effectiveness of instructional television unless it is used to aid discrimination or where colour is itself part of the learning task Coldevin (1981) also reports on numerous 'no significant difference' results from comparison studies between colour and black and white

programmes (for example, Frey, 1970, Kaneko, 1971 and Kanner & Rosenstein, 1960)

Webster and Cox (1974) undertook research to determine if colour, "used in a careful and selective way" in educational programmes, could improve learning from television. In these studies colour captions were used to present summarised information at intervals. The experimental treatment featured colour changes to signify the more important summaries, the treatment for the control group had no colour changes. Two versions of the experiment were carried out, in the first version the subjects were not informed of the significance of the colour changes, in the second version the subjects were informed. When the subjects were given no guidance, no significant difference between the recall of the treatment and the control group was found. However, when the subjects were informed in advance of the reason for the colour changes, a significant difference was found. These results highlight the interaction between technical variables and the instructional context. Webster & Cox suggest that in the latter case the subjects were in a state of preattention, ready to perceive and take notice of the colour changes, whereas in the case where the learners were not informed they 'filtered out' what they perceived as non relevant additional stimuli, namely the colour changes.

Summary of Review of Research

This study investigated motion and manipulation in television, spatial ability, and the learning of visual concepts

and principles Previous ATI research has shown that task, learner and treatment characteristics can combine to produce complex performance differences and as Rhetts, (1974) points out, researchers cannot simply 'throw together' combinations of three variables A good match between the instructional treatment variable and the moderating aptitude is essential if meaningful results are to be obtained Salomon has shown how dynamic television presentations can help students develop certain skills, he has also identified some unique attributes of television that match certain psychological functions In this context, Salomon (1979, pp 91-92) points to television's ability to show objects being moved, rotated and manipulated and the psychological function of mental imagery

"Consider a static picture of objects in space and a task requirement to show how these objects will look after a 270° rotation Certain mental skills can be assumed to be activated under such conditions Now, consider a film that actually shows how these objects rotate in space Obviously, such a film would make the task relatively easy, as it supplants the imagery processes that are required by the task Whereas wide individual differences would be observed in the former case, a narrower range of variation would appear in the latter, as the film renders one's imagery skills relatively unnecessary

The processes by which we learn certain concepts and principles from pictures may involve the skills which Salomon has shown can be cultivated and supplanted by the television symbol systems Investigating the relationship between a persons existing imagery skills and ability to learn

from televisual sequences that present visual concepts and processes, is a logical extension to this line of research

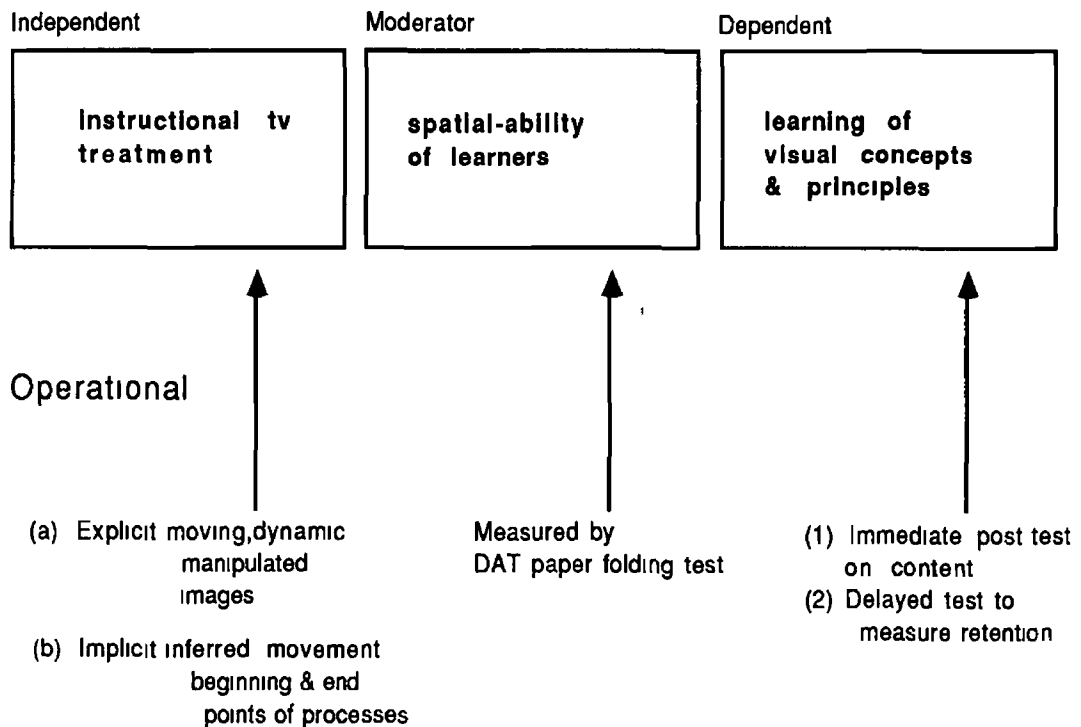
Chapter Three - Experimental Methodology

Introduction

The aims of this study were to evaluate the instructional effectiveness of television sequences containing varying degrees of movement and dynamic realism and the extent to which spatial ability influences this type of learning. Figure 3.1 illustrates the variables involved and their operational measures.

Figure 3.1

The Research Variables



The Hypothesis

Definition of Explicit and Implicit Treatments

The modern TV producer can choose from a variety of options available when presenting visual concepts and processes. By taking full advantage of the animation systems and computer imagery available, a strategy of explicit representation of the concepts and processes involved, may be adopted. For example, a sequence showing the movements of the planets about the Sun may present a dynamic and realistic account of the planets moving through their respective orbits. An alternative strategy may be to implicitly represent the pathways involved using only arrows or dotted lines to show the direction and track. These two production strategies differ in relation to their internal processing demands. With the explicit presentation the learner is provided with a direct representation of each step in the process, the visual sequences through animation and transformations, provide the learner with an 'easy' pathway demanding little by way of internal manipulation and processing. Alternatively with the implicit presentation the learner is expected to internally manipulate and transform the visuals in order to work out the processes involved. The effectiveness of either of these approaches will depend on the mental skills already available to the learner (Salomon, 1979). These approaches represent two extremes along a realism continuum of representation of motion.

Statement of the Hypothesis

When a television presentation is used to teach visual concepts and principles by means of large group instruction to fifteen year old Irish school children, an aptitude by treatment interaction between the participants spatial ability and the level of explicitness of the treatment will be found. The interaction will be of the following form

Students of low spatial ability will benefit more from an explicit version of the treatment than from an implicit version of the treatment

Students of high spatial ability will benefit more from an implicit version of the treatment than from an explicit version of the treatment

Rationale for the Hypothesis

It is proposed that the explicit and implicit versions of the programmes would work differently for students of different spatial ability. Students of low spatial ability would be expected to perform better with the explicit version, as the animated sequences would compensate for their deficiencies of manipulative skills. Students of high spatial ability, on the other hand, should perform better with the implicit version because their own well developed manipulative skills would enable them to work out the concepts and processes for themselves. And, with the implicit version they would avoid the visual interference of the animated television graphics.

Operational Restatement of the Hypothesis

When explicit and implicit versions of the television programme "Making the Most of the Sun", are used for large group instruction to 15 year old secondary school children

An analysis of the immediate comprehension post-test scores for both treatment groups and the students spatial ability as measured by the DAT Space Relations test, will reveal an aptitude by treatment interaction of the following form

Students defined as having low spatial ability who view the explicit version of the treatment will perform better than students defined as having low spatial ability who view the implicit version of the treatment

Students defined as having high spatial ability who view the implicit version of the treatment will perform better than students defined as having high spatial ability who view the explicit version of the treatment

also

An analysis of the retention of comprehension (delayed) post-test scores for both treatment groups and the students spatial ability as measured by the DAT Space Relations test, will reveal an aptitude by treatment interaction of the following form

Students defined as having low spatial ability who view the explicit version of the treatment will perform better than students defined as having low spatial ability who view the implicit version of the treatment

Students defined as having high spatial ability who view the implicit version of the treatment will perform better than students defined as having high spatial ability who view the explicit version of the treatment

Experimental Design

The experimental design was an factorial modification of the Post-test-only Control Group Design (Tuckman, 1978), shown in FIG 3 2 The design used three groups two of which experienced versions of the treatment, the other group, the control group, received no treatment

The absence of a pretest controlled for possible testing effects brought about by interactions between the pretest and the post-test and the pretest and the treatment (Tuckman,1978)

FIGURE 3 2

<i>Factorial Modification of Post-test only Control Group Design</i>				
R	X ₁	Y ₁	O ₁	O ₇
R	X ₁	Y ₂	O ₂	O ₈
R	X ₂	Y ₁	O ₃	O ₉
R	X ₂	Y ₂	O ₄	O ₁₀
R		Y ₁	O ₅	
R		Y ₂	O ₆	
<i>Treatments (X)</i>	X ₁		<i>explicit treatment</i>	
	X ₂		<i>implicit treatment</i>	
<i>Moderator (Y)</i>	Y ₁		<i>high spatial ability</i>	
	Y ₂		<i>low spatial ability</i>	
<i>Observations</i>	O ₁ to O ₆		<i>immediate post-test</i>	
	O ₇ to O ₁₀		<i>delayed post-test</i>	

The Sample

The sample was composed of 200 school students, 105 male and 95 female from Coláiste Chiaráin community school, situated in Leixlip, County Kildare, Ireland. The mean age of the participants at the time of testing was 15.15 years.

Demographic statistics based on fathers occupation were gathered for a similar sample of students from the same school in 1986 by Mulkeen, Hodgins & Ní Mhurchú (1986) The study reported the social class mix of the school to be middle class, 62.5%, working class, 27% and unemployed, 10.5%

The Spatial Skills Pretest

The Differential Aptitude Tests

All students from the sample year group were given the Differential Aptitude Tests -form T(DAT) (Bennett et al, 1974) eight weeks before the experimental procedure DAT tests are administered annually as part of the careers counseling programme These were administered by the school's full-time careers' councillor The counsellor worked closely with the researcher and she was aware that the results would be used to classify the participants for the experimental study The tests were administered and scored in accordance with the directions given in the Administrator's Handbook, Differential Aptitude Tests (1982)

The DAT scales are designed to measure specifically defined abilities and achievements The measures include six basic aptitude and two achievement variables, they are Verbal Reasoning -a comprehension test using analogies, Numerical Ability -a computation type test embodying only arithmetical principles, Abstract Reasoning -a figural

reasoning test, Clerical Speed and Accuracy -perceptual speed test requiring quick and accurate perception of similarities and differences, Mechanical Reasoning -requiring an understanding of basic physical properties, Space Relations - a test of mental manipulative skills using mental paper folding The two achievement tests are Spelling -involving recognition of misspelled words and Language Usage - involving the recognition of poorly formed or non-grammatical sentences

The Space Relations test,a 25 minute test containing 60 items, consists of a series of patterns that can be folded into figures The student is shown a picture of the object which has been laid flat and unfolded, and must identify which *figure from among four choices* can be made from the pattern This test represents a combination of two approaches to the measurement of spatial ability the ability to visualize an object constructed from a given pattern or net, and the ability to imagine how that object would appear, if rotated in various ways (Smith,1964) Sheenan et al (1983) and Smith (1964) judge the DAT Space Relations test as an acceptable test of spatial ability

The Differential Aptitude Tests are currently among the most widely used measures of multiple aptitudes First published in 1947, they have been regularly revised and restandardised since then (Pennock-Román, 1985) They were designed principally for vocational counseling of students in the 12 - 17 years age group The DAT tests have also been used for an impressive array of basic research on the nature

of achievement and aptitudes, including the relationship between DAT scores and visual short term memory and age (Adamowicz & Hudson, 1978), visual imagery (McKelvie & Rohrberg, 1978) and cross-modal spatial ability (Kumar, 1975) They have also been used to study information processing demands on test items (Whitely, 1977)

Reliability

Most of the Differential Aptitude Tests were reported (Bennet et al, 1972) to have generally high reliability coefficients (Space Relations 93 for boys and 90 for girls) These coefficients represent internal consistency measures for the tests using the split-half procedure and the Spearman-Brown formula

Validity

As pointed out by Anastasi (1982, p 375), "the amount of validity data available on the DAT is overwhelming, including several thousand validity coefficients" most of these data are concerned with predictive validity in terms of both vocational and academic programmes Intercorrelations between Space Relations and other DAT scores range between 5 and 6 (Bennet et al , 1972)

Norms

The tests form T were standardized in 1975 on over 10,000 students in Ireland (Killehan et al, 1975) and Irish norms are available A Differential Aptitude Test processing

service is available in Ireland¹ and processed scores are given as raw scores, centiles and standard scores

For this study the raw scores from the Spatial Relations test were used as the measure of spatial aptitude for the experimental sample

The Instructional Treatments

Content Selection and Production Rationale

The treatments consisted of two versions of a 15 minute instructional video programme on the subject of solar energy. The video programme was specifically designed and produced by the researcher for this experiment. The instructional topic, passive solar heating, was chosen for a number of reasons - it involved a variety of mainly visual concepts and processes, - it was a science based topic that would not normally have been taught to Irish school students, - many of the processes involved were dynamic in nature and, because the subject matter related to Irish housing and Irish climatic conditions, it would be an interesting and a relevant extension to the normal science course.

Passive solar heating represents an innovative approach to building and designing energy efficient housing. It involves the application of some basic physical principles to housing architecture. In temperate climates where conventional solar energy systems are not feasible the use of passive solar

¹ Educational Research Centre, Drumcondra, Dublin 9, Ireland

heating is being encouraged (for example Project Monitor a European Community programme for education of Architects)

The Instructional Objectives

Gagné and Briggs (1979) recommend that the first step in an instructional design process should be a statement of objectives. They make a distinction between two types of objectives: *target objectives*, which are statements of the final achievements expected at the end of an instructional course, and *enabling objectives*, which must be attained during a course of study because they are prerequisites to the former type.

The target objectives for this instructional treatment are set out below, they are stated behaviorally (Gagné and Briggs, 1979). The relevant post-test questions are given in brackets at the end of each statement.

(1) Convection Current (Concept)

Given diagrams showing a contained area and a heat source, the student identifies the convection current, by selecting the correct path, or vent locations { Questions (1), (9) and (10)}

(2) The Greenhouse Effect (Concept)

Given diagrams showing a containers with combinations of transparent, reflecting or absorbing sides and a directional radiated heat source, the student identifies the greenhouse effect, by selecting the correct combination of sides { Questions, (3), (8) and (12)}

- (3) The use of South facing windows in house design (principle)

Given diagrams that show combinations of roof and wall locations for windows, the student demonstrates the South facing window principle, by selecting the most energy efficient combination { Questions, (2), (5), and (11)}

- (4) The changing position of the Sun in the Summer/Winter sky (principle)

Given diagrams that show combinations of roof and window configurations, the student demonstrates the Summer/Winter Sun position, by selecting the most energy efficient configuration { Questions, (2), (5), (6), (13), (14) and (16)}

- (5) The position of the Sun in the Northern and Southern hemispheres (principle)

Given diagrams that show combinations of roof and window configurations and statements about the location of the house on the Earth, the student demonstrates the Northern/Southern Hemisphere Sun position, by selecting the most energy efficient configuration { Questions, (2), (5), (6), (11), (13), (14), (15), and (16)}

- (5) The Summer/Winter self-regulation of South facing windows (principle)

Given diagrams that show combinations of roof and window configurations and statements about the location of the house on the Earth, the student demonstrates the Northern/Southern Hemisphere Sun position, by selecting the most energy efficient configuration { Questions, (2), (5), (6), (11), (13), (14), (15), and (16)}

- (6) The use of roof overhangs for seasonal solar regulation (principle)

Given diagrams that show combinations of roof overhang design, the student demonstrates the seasonal solar regulation effect, by selecting the most energy efficient design { Questions, (6) and (16)}

- (7) The shading effects of different types of trees (principle)

Given diagrams that show combinations of tree types and siting with respect to houses, the student demonstrates the shading effects of different tree types, by selecting the most energy efficient configuration { Question (11)}

- (8) The Trombe wall (concept)

Given diagrams that show combinations of internal and external wall, and window configurations, the student identifies the Trombe wall, by selecting the most energy efficient configuration { Questions, (4), (7), and (10)}

- (9) The use of convection vents in house design (principle)

Given diagrams that show combinations of internal wall, heat source and convection vent configurations, the student demonstrates the use of convection vents in house design, by selecting the most energy efficient combination { Questions, (9), and (15)}

- (10) The use of moveable insulators/reflectors (principle)

Given diagrams that show combinations of window, wall and insulator position and statements about the time, the student demonstrates the principle of moveable insulators, by selecting the most energy efficient position { Questions, (13) and (15)}

Most of these are design principles that apply the science of passive solar heating to house construction and positioning

Enabling objectives for this course were

- *given multiple examples of heat transmission via conduction, convection and radiation, the student will identify examples by placing CON, or COND or RAD underneath the correct response*
- *given an energy band diagram of the electromagnetic spectrum, the student will be able to identify the positions of light and heat energy by shading the correct regions of the diagram*
- *given pictures that show multiple examples of deciduous and evergreen trees, the student will be able to identify the examples, by placing D or E underneath each example*

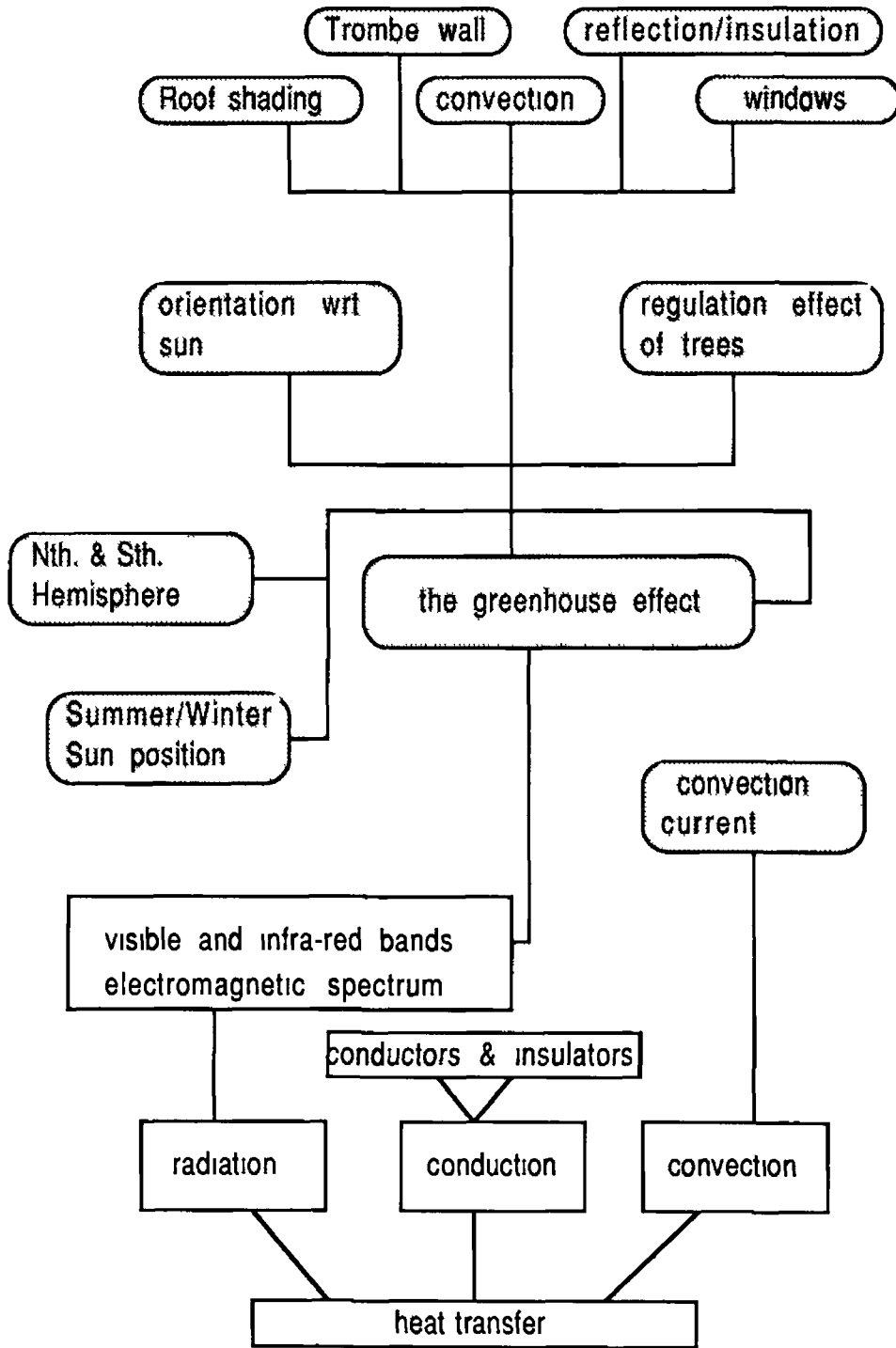
Task Analysis

Most instructional theories recommend that some form of task analysis involving the classification of the types of learning required, should precede the design process (Romiszowski, 1974, Anderson, 1976 and Gagné & Briggs, 1979) In this instance the research question centres on the learning of concepts and rules and the terminal objectives are stated in terms of these Figure 3 3 (page 70) is a flow

diagram representing an analysis of the learning task. The figure shows how knowledge of the concepts of heat transfer and electromagnetic radiation are prerequisite to the greenhouse effect. Some of these prerequisite concepts are part of basic school Physics and would have been previously taught to the participants. However, instruction on these prerequisites was included in the treatments, so that any effects from different levels of prior knowledge levels could be minimized.

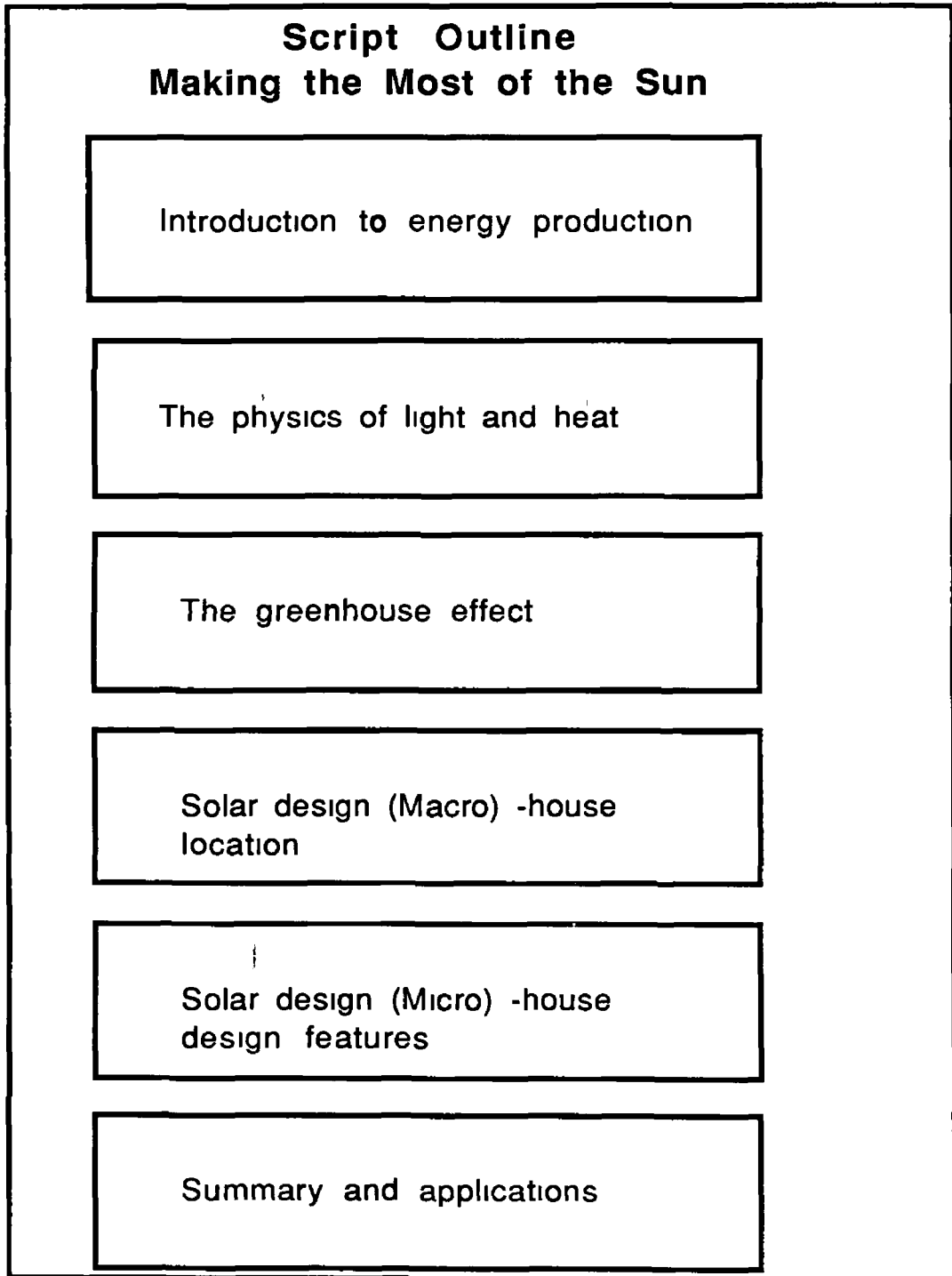
Figure 3.4 (page 71) shows an outline of the instruction. The programme begins with an introduction to energy production. The rationale for a new way of thinking about energy production and conservation is established by drawing attention to the fact that in Ireland most energy is produced by means of burning fossil fuels and that these fuels will not last forever. Some of the physical concepts of light, heat and electromagnetic energy transfer are presented and demonstrated. The greenhouse effect, which is a principle (or rule) involving some of these concepts, is demonstrated and explained. Macro solar design principles, involving the location and positioning of buildings and micro solar design principles, involving actual house construction, are then established. The programme concludes with a summary of the new concepts and principles that were presented.

Figure 3 3 Task Analysis Flow Diagram



Note shading denotes terminal objectives

Figure 3.4 An outline of the Instructional Treatment



The Development and Formative Evaluation of the Treatment

Based on the objectives and the task analysis quoted above, a first draft of the programme script was prepared. In addition to the direct instructional sequences, the finished programme was designed to meet the following additional criteria

- the experimental sequences would be embedded within an educational television programme made to high possible technical and production standards

- the scientific and architectural programme content would be accurate and relevant

Experts in television production¹, experimental physics² and architecture³ were consulted during the formative stages of the programme design. The development of the programme content, the wording of the script, and the design of the visuals took place in accordance with the advice and approval of these experts. They also viewed the finished master-tapes and certified that the programmes fulfilled the stated criteria.

Research has highlighted the importance of the rate and the level of complexity of verbal information accompanying

¹ Michael Foley, Director, Audio Visual Centre, University College Dublin

² Dr J A Scott, Dean of Science, University College Dublin

³ Loughlin Keily, Dept of Architecture, University College Dublin

pictorial information (Travers, 1966) The pace, wording and composition of the programme voice-over were subjected to an informal evaluation process. The researcher gave a series of classes to students of the same age group as the sample but from a different school⁴. The classes were given using overhead transparency versions of the visual sequences. The classroom presentation followed the television programme voice-over as closely as possible. A discussion on the content took place at the end of each class. These classes provided feedback about the level of difficulty of the instructional presentation and the students' attitudes toward passive solar energy. Many of the words and phrases used in the original draft of the script were re-written and simplified. An additional indication of the level of difficulty of the script was obtained by calculating its reading difficulty by using Gunning's (1972) Fog Index. This index measures the average sentence length and the percentage of long words in passages and matches this to the reading age of the student. The index is designed for reading rather than spoken text, however, the voice-over script was simplified so that the readability was matched to that of 15 year olds.

The programme also included sections designed to motivate viewers as to the desirability of passive solar heating. The supportive effect of positive attitudes on the learning of intellectual skills is widely recognised (Gagné,1985). For example, Mager (1968) speculates that the

⁴ School CBS Lucan, Co Dublin, class teacher Agnes Hachett

attitudes of a learner toward a subject strongly influence the ease with which a subject is learned, retained and put to use. The viewers would not previously have encountered the ideas of passive solar heating, it was therefore necessary to establish its worth and usefulness.

The Television Production Process

The programme format consisted of three main production elements: a presenter in studio, graphical sequences, and a presenter on location. A lively attention getting opening sequence and a number of relevant location cutaways were also included. The general style was that of a modern science educational programme hosted by a professional presenter. The programme title was "Making the Most of the Sun". In studio the presenter was shown against a keyed background depicting the sun and clouds. Most of the viewers who participated in the study would have known of the programme's presenter (Brian Hayes) who presented a popular television programme on science and technology broadcast by Radio Telefís Éireann, Ireland's national television station.

Broadcast or near broadcast standard technical equipment used in production of the programme. The video recording format was low-band U-matic (Sony type V) connected to a three tube colour video camera (JVC KY320). The graphical sequences were composed on a Quanta paintbox, a high quality computer graphics facility capable of producing complex well-defined two dimensional colour visuals.

Animation and motion effects were created by using a combination of conventional animation techniques and the mixing facility of a two channel frame store (Gemmini 2) Conventional animation involves recording individual pictures at two or four frame intervals (there are 25 different frames in one second of moving television) A frame store can hold a picture or television frame in digital form and a two channel version is capable of dissolving between two pictures A series of dissolves can give the impression of movement, this technique is often used on broadcast television

The Instructional Rationale

The complete programme script is presented in Appendix A The the instructional design approach was based on guidelines derived from the theories proposed by Gagné and Briggs (1979) Typically, a new concept is introduced by a definition involving it's critical attributes The learner is then presented with a number of examples and non-examples When new principles are taught, the component concepts are first introduced and then the learner is shown how these concepts relate to one another

The following example from the script demonstrates the typical strategy used for presenting a new concept

Dialogue

The second way in which heat energy can be transferred is by conduction, in this case the heat is transferred along some medium known as a heat conductor¹ Some materials like metals, are good conductors of heat² You can feel conducted heat when a poker is placed in a hot fire³ Other materials do not conduct heat as easily, these are known as insulators⁴ An example of a good heat insulator is wool⁵, a pair of gloves will prevent the heat from your hands from being conducted along the handlebars of a bicycle on a cold morning⁶
note ("\" denotes a cut)

Rationale

¹Definition of the concept, ²General example, ³Specific example, ⁴ Name for non-examples, ⁵ Non-example general, ⁶ Non-example specific

Visuals

presenter to camera
text graphic,
"conduction"
picture with text
"conductor" shows heat (symbolised by colour red) being transferred along the medium picture of hand on poker, radiating slash lines depicting the hand feels hot text graphic
"insulators" presenter to camera, holds up a pair of woollen gloves

The Two Treatment Levels

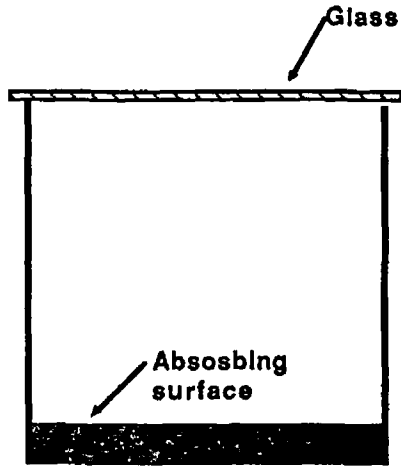
Two versions of "Making the Most of the Sun" were produced, they were identical in every respect except for the amount of dynamic illustration used to depict movement. The "explicit" version used animation and rapid dissolve techniques whenever possible to show movement or change, whilst the "implicit" version used still visuals with cue arrows to show the direction of the implied movement. For a sequence involving an object moving from a location A to a location E, the explicit version would show the object moving through the intermediate stages A to B to C to D to E, the implicit version would only show the object at A and then at E. The voice-over was the same for both versions.

The difference between the two treatment levels may be regarded in terms of the instructional task presented to the learner. It was expected that the explicit version would place little demand on the spatial manipulation skills of the learner, whereas the implicit version would require that these skills be used in order to understand the visual sequences.

The following examples from the script show just how the two versions of the treatment differ.

[1]

THE GREENHOUSE EFFECT

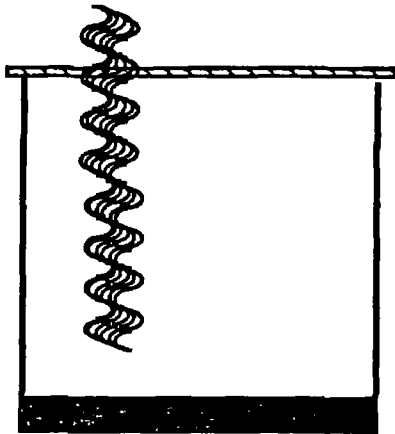


No difference between
the Explicit and the Implicit
versions

Voice-over The greenhouse effect works like this In its simplest form we have an enclosed space with a glass roof to allow the sunlight through and a surface which can absorb heat energy

[2]

Sunlight

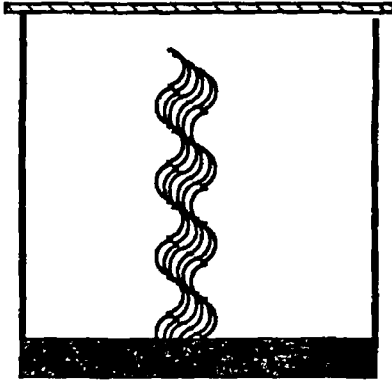


Explicit Version - light
waves can be seen actually
passing through the glass
surface

Implicit Version -
shows no movement

Glass is transparent for visible light which we already know is electromagnetic energy of a particular band of wavelengths, it allows these wavelengths to pass through into the enclosed space The glass is transparent for these bands of electromagnetic radiation

[3]



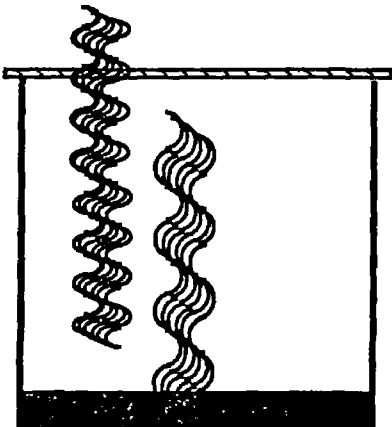
Explicit Version -
absorbing surface at the
bottom is shown changing
colour as it absorbs the
sunlight, the re-radiated
energy is animated

Implicit Version - no
colour change or movement
is shown

*The absorbing surface at the bottom will take in this
energy but it will itself begin to radiate heat energy back into
the enclosure,*

[4]

Sunlight



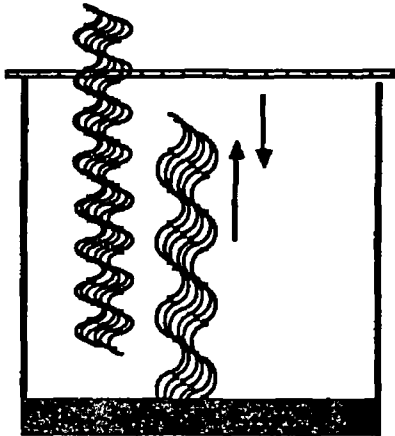
Explicit Version - both
the incoming and the re-
radiated waves are
animated

Implicit Version - both
waveforms are shown static

*this re-radiated energy has a longer wavelength than the
incoming energy and glass is not transparent for these longer
wavelengths,*

[5]

Sunlight



Explicit Version -

waves move up and are shown being reflected back into container

Implicit Version -

only the arrows are used to indicate the direction of the movement

the heat energy is trapped inside the enclosure and therefore the temperature increases

Appendix A clarifies the differences between the explicit and the implicit treatment levels for all of the other terminal objective concepts and principles. Apart from these differences the two treatments are identical.

The Criterion Post-tests

Visual Testing

One of the most consistent criticisms of research on visual learning is that it is evaluated via text based criterion tests (Dwyer, 1987, Szabo et al, 1981 and Dwyer & Del Melo, 1983). The current theoretical approaches to information acquisition and retrieval processes (outlined in chapter one) would suggest that we process visual and verbal symbols

differently. The dual-coding theory (Paivio, 1971) proposes that information can be processed on several levels simultaneously, and that this processing enhances its entry into long term memory. Although the dual encoding and retrieval systems are perceived as functioning as separate entities, they also possess the capability of functioning in unison with each another.

A true assessment of learner information acquisition can therefore only be made when retrieval cues are of the same form as the original instruction (Tulving & Thompson, 1973). If visualization is an integral component in facilitating learner encoding of the information, then visualization should also be used in the test items.

Development and Evaluation of the Post-tests

A criterion referenced visual test to measure attainment of the target objectives was constructed. The complete test is presented in Appendix B. To maximize content validity the instructional objectives (pages) were used as the basis for the test questions (Tuckman, 1978). The examples used in the treatment were modified sufficiently so that the test questions measured the application of the concepts and principles and not just recall. Many of the questions involved combinations of two or more principles and all of the questions presented the learners with new and novel situations.

A multiple choice format similar to that used by Dwyer (1972) was chosen. The development of the questions was

subjected to the same formative evaluation procedures as the script development. The physics and architecture subject experts reviewed the visual tests and a number of changes in the wording and the diagrams were recommended and subsequently carried out.

Prior to the experiment, the tests were also administered to a pilot group and an item analysis as suggested by Tuckman (1978) was carried out. The pilot group consisted of a class (n=15) from the same year group and school as the experimental sample. This class consisted of all boys who were not included in the experimental sample. The pilot also provided an indication of the time required to administer the treatment and the test. The total time available was limited by the duration of a class period to 35 minutes. As the duration of the video treatment was 15 minutes, and eight minutes were allowed for setting up the equipment and introducing the television programme, the test was limited to 12 minutes duration. The results of the pilot indicated that there were too many questions for the time allowed and the original 19 items were reduced to 16. The three questions with the lowest 'indices of discriminability' (Tuckman, 1978) were eliminated.

Reliability

The test reliability was computed using the Kuder-Richardson 21 formula (Tuckman, 1978), the reliability coefficient ($r = .62$) shows acceptable reliability.

Experimental Procedure

The experimental procedure was carried out in the ten days between April 18-28, 1988 at Coláiste Chiaráin Community School, Leixlip, County Kildare, Ireland. A total of 200 students were tested. As the school administrators preferred not to sub-divide classes for experimental purposes, normally distributed intact classes were used (Tuckman, 1978). Students in this school are streamed for certain subjects (English, Irish and Mathematics) and are assigned to mixed ability classes for other subjects, including Science. This assignment takes place at the beginning of the school year. The assignment procedure is as follows: students are classified on the basis of their previous year's combined results for the three streamed subjects as low, middle or high achievers, each mixed ability class is then made up as one third low, one third middle, and one third high achievers, individual selection to a particular class from within the achievement groups is on the basis of a random number procedure. Ten of the mixed ability Science classes participated in the study. Spatial Ability was shown to be randomly distributed in equivalent class groups (Figure 4.2). For the purposes of the experiment these were treated as random groups.

Four science teachers share the teaching load, all students were being prepared for the national Intermediate Certificate Exams held in June 1988. The subject matter of the instructional treatment (Passive Solar Heating) was not on the syllabus for the Intermediate Science Exam and the

students had received no instruction on Passive Solar Heating prior to the testing procedure

In order to operate within the constraints of the school timetable, the complete testing procedure had to be carried out within one 35 minute class period. The duration of the television treatment was 15 minutes, the immediate post-test took 12 minutes leaving eight minutes for setting up and introducing the programme.

All the participants were told that they were involved in an educational experiment. They were asked to concentrate on the programme as they would later have to answer questions on the content. The post-test was administered immediately after the video. The multiple choice post-test consisted of a four page question sheet with answer boxes provided, the participants all received the same instructions on how to use the answer boxes. Throughout the class period the classes were supervised by the class teacher and by the researcher.

During the first two days, six of the total of ten classes were tested. The following week the final four classes were tested. The ten class groups were considered as ten random groups for this experiment. This can be justified as the students were originally randomly assigned to their science classes and no class had received special instruction on the treatment topics. The average number of students in each class was 20. Eight classes were randomly assigned as treatment groups, four were shown the "explicit" version of

the television treatment and four were shown the "implicit" version. Two other class groups were assigned as control groups, they were shown a video on inner city development containing no relevant instructional content.

Each video programme was played on a 3/4 inch video cassette recorder connected to a 27 inch television monitor. The class was placed so that all of the viewers were seated between two and six screen widths from the monitor (McVey, 1970). The maximum horizontal viewing angle was less than 30 degrees for students nearest the monitor (Gordon, 1975). Viewing and lighting conditions for all classrooms was kept as uniform as possible.

The criterion post-test on the comprehension of the concepts and processes introduced in the video programme was administered immediately after the treatment. The same post-test was administered to all treatment groups. A delayed post-test was administered four weeks after the treatment in order to determine the retention effects. Participants were not told in advance that there would be a delayed test. In the intervening period they received no additional instruction on the test material.

Data Analysis

Test Scoring

The multiple-choice post-tests were marked by the investigator, one point was awarded for each correct response. Responses that were wrong, missing or ambiguous

were scored as zero. The total score for each student was recorded on a computer based coding frame.

The participants were classified as either high, low or middle spatial ability. Following Carrier and Clark (1978), students who scored 5 standard deviation or more above the sample mean, were classified as high spatial ability. Students who scored 5 standard deviation or more below the mean score were classified as low spatial ability. All others were classified as middle spatial ability. As recommended by Cronbach and Snow (1977) only the two extremes high and low spatial ability, were considered for the analysis of variance and comparisons between the means. The total sample spatial abilities were considered for the correlation analysis.

Statistical Procedures

A series of two factor analysis of variance procedures were used to test for the main effects. One directional independent t-tests (Tuckman, 1978) were used to assess the level of significance of differences between the means. All significant differences are reported at the .05 level. A sample size of 200, with $s_d = 2.5$ and $\alpha = .05$ can detect an effect size of .35 (Hopkins and Glass, 1978).

Many of the statistical tests were carried out using the StatView 512+ (Abacus Concepts, Inc) programme package for Apple Macintosh. For verification purposes analysis were repeated using the worksheets provided by Tuckman (1978). The StatView package generated the regression analysis shown in figures 4.6 to 4.8.

Chapter Four - Results

Figure 4.1 shows the distribution of the total sample by means of treatment and spatial ability. Spatial scores were not available for twelve of the students, their results were not included in the data analysis. For school organisation reasons, fewer students were available for the delayed tests. The degrees of freedom and denominator values were adjusted accordingly in reporting these results.

Figure 4.1

Distribution of Total Sample by means of Treatment and Spatial Ability

Rated Spatial		low	middle	high	Totals
Treatment	Explicit	29	31	23	83
	Implicit	23	18	30	71
	Control	10	16	8	34
Totals		62	65	61	188

The spatial ability means and standard deviations are shown in figure 4.2. To determine whether spatial ability was randomly distributed in equivalent groups, a three way analysis of variance of spatial score was performed. The results are also shown in figure 4.2. The analysis of variance shows no significant difference between the groups. The groups can therefore be considered as equivalent in terms of spatial ability.

Figure 4.2

**Spatial Ability Means and Standard Deviations for the
Three Groups**

	Count	Mean	Std Dev	Std Error
Explicit	83	31 289	10 002	1 098
Implicit	71	33 38	10 217	1 213
Control	34	31 559	10 439	1 79

Analysis of Variance Table

Source	DF	Sum Squares	Mean Square	F test
Between groups	2	180 761	90 381	875
Within groups	185	19106 175	103 277	p = 4185
Total	187	19286 936		

To verify that the learning gains as measured by the criterion test were in fact due to the instructional treatments, a comparison was made between the immediate post-test scores of the treatment and the control groups

The treatment and control group's score means (9 86 & 4 44) are presented in table 4 3. The significance of the difference between the means was measured by a one-tailed independent t-test, the results of which are also shown in Table 4 3. The test revealed a significant difference ($t=11.879$, with 198 degrees of freedom, $p < .05$) in favour of the treatment groups.

Table 4.3

**Unpaired t-Test,
Treatment vs. Control Group
Immediate Post-test Means**

Group	Count	Mean	Std Dev	Std Error
Treatment	164	9.86	2.612	204
Control	36	4.444	1.715	286

DF	Unpaired t Value	Prob (1-tail)
198	11.879	1.0000E-4

Analysis of Variance

Immediate Post-test

The main effects of the independent and the moderator variables were examined using a 2 by 2 analysis of variance. Following the advice of Cronbach & Snow (1985) only the high spatial and low spatial ability groups were considered. The results for the immediate post-test are shown on Table 4.4. Spatial ability is shown to be a significant moderator variable ($f=40.198, p < .05$). However, no significant difference was found between the two treatment means ($f = 236$). The interaction between the two variables was not significant.

Table 4 4

**Anova table for a two-factor
analysis of variance on post-test scores**

Source	df	Sum of Squares	Mean Square	F-test	P value
Exp/Imp Treatment	1	1 161	1 161	236	628
High/Low Spatial	1	197 545	197 545	40 198	1 0E-4
AB	1	016	016	3 219E-3	9549
Error	103	506 177	4 914		

The associated incidence table

High/Low Spa		low	high	Totals
Exp/Imp	Explicit	29 8 621	23 11 391	52 9 846
	Implicit	23 8 435	32 11 156	55 10 018
Totals		52 8 538	55 11 255	107 9 935

The Retention Test

Table 4 5 shows the analysis of variance for the retention test scores. The type of treatment was shown to be significant ($f=6 832$, $p< 05$) as was the moderating effect of spatial ability ($f=14 128$, $p< 05$). The interaction between the two variables was significant ($f=4 145$, $p= 05$)

Table 4.5

**Anova table for a two-factor
analysis of variance on retention test scores**

Source	df	Sum of Squares	Mean Square	F-test	P value
Exp/Imp Treatment	1	49 299	49 299	6 832	0107
High/Low Spatial	1	101 941	101 941	14 128	3 0E-4
AB	1	29 907	29 907	4 145	0451
Error	79	570 023	7 215		

The associated incidence table

High/Low Spa		low	high	Totals
Exp/Imp	Explicit	14 8 357	16 11 938	30 10 267
	Implicit	22 8	31 19 065	53 8 623
Totals		36 8 139	47 10 043	83 9 217

Regression Analysis

Figure's 4 6 to 4 8 use regression lines to illustrate graphically the relationships between the variables

Figure 4 6 shows the immediate post-test scores for each of the treatments regressed against spatial aptitude scores

Figure 4 7 shows the retention-test scores for each of the treatments regressed against spatial aptitude scores

Figure 4 8 shows the results of the retention test scores of the treatment groups together with the control group

Figure 4.6

Immediate post-test vs. spatial score

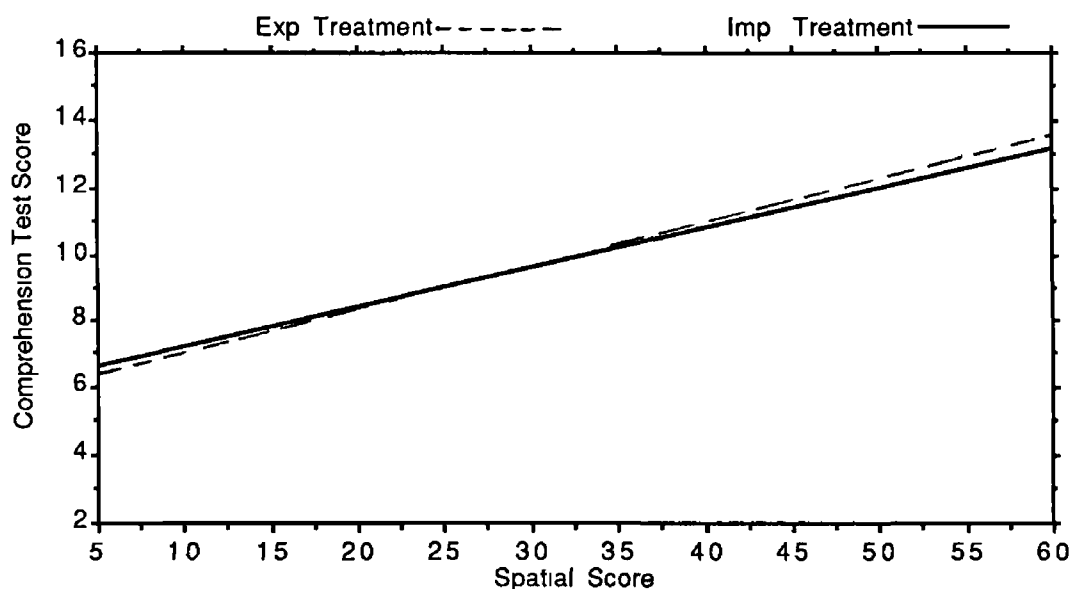


Figure 4.7

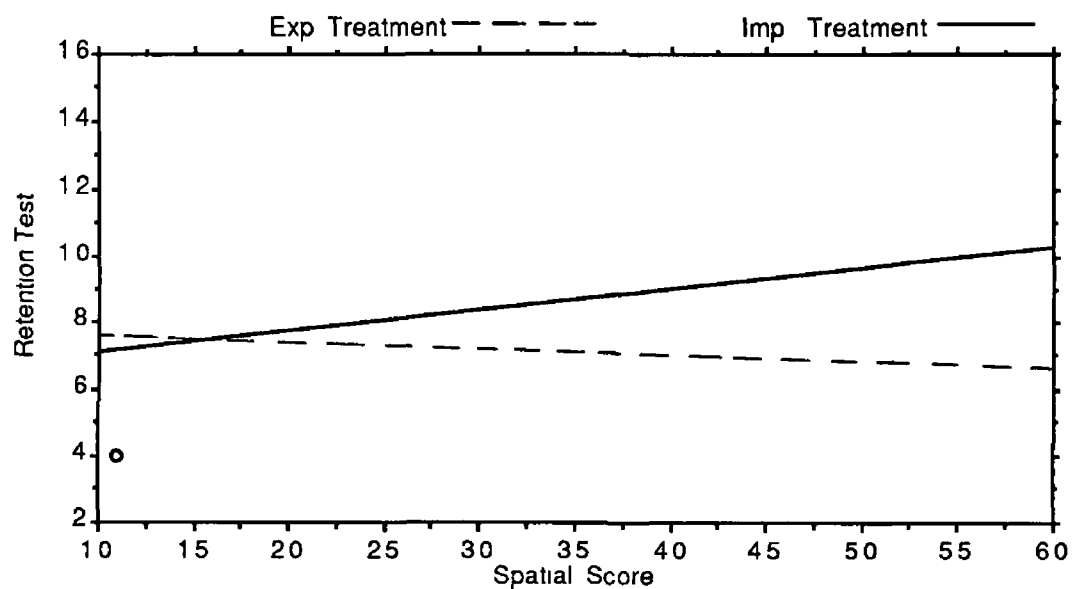
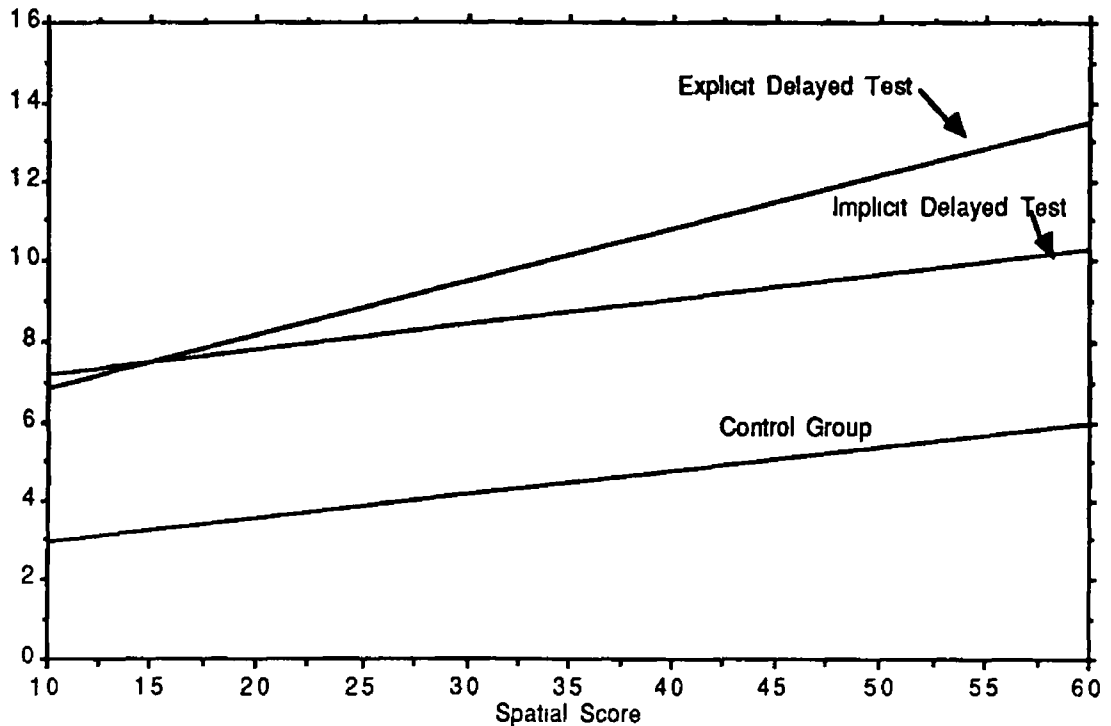


Figure 4.8

**Control group post-test and treatment's retention test
vs. Spatial Score**



Comparisons between the Means

Total Treatment Groups

Mean scores and standard deviations for the immediate post-test for both treatment groups regardless of spatial ability are presented in table 4 9 The difference between the means (9 77 & 9 961) was not significant ($t= 466, 162$ degrees of freedom)

Mean scores and standard deviations for the retention-test for both treatment groups regardless of spatial ability are presented in table 4 10 The difference between the

means (9.61 & 8.548) was significant ($t=1.88$, 112 degrees of freedom, $p<.05$) The explicit treatment was shown to be more effective than the implicit treatment across the total sample

Table 4.9

Immediate Post-Test, Mean Scores, Standard Deviations and T-test

DF		Unpaired t Value		Prob (1-tail)	
162		- 466		3209	

Group	Count	Mean	Std Dev	Std Error
Explicit	87	9.77	2.514	.269
Implicit	77	9.961	2.731	.311

Table 4.10

Retention Test, Mean Scores, Standard Deviations and T-test.

DF		Unpaired t Value		Prob (1-tail)	
112		1.884		.0311	

Group	Count	Mean	Std Dev	Std Error
Explicit	41	9.61	3.089	.482
Implicit	73	8.548	2.769	.324

In order to further examine the effects of the moderator variable, a more detailed analysis of the means for the low, and high spatial ability groups was carried out

Low Spatial Ability- Post-Test

A one tailed independent t-test was used to test for significant differences between the means of the two treatment groups for the low SA participants. The difference between the two means (8 621 & 8 435) on the immediate comprehension post-test test are shown in Table 4.11. The difference was not significant.

Table 4.11

Unpaired t-Test exp /imp. post-test scores for low SA participants

Group	Count	Mean	Std Dev	Std Error
Explicit	29	8 621	2 128	395
Implicit	23	8 435	2 428	506

DF	Unpaired t Value	Prob (1-tail)
50	294	385

Low Spatial Ability- Delayed Test

A one tailed independent t-test was also used to measure the significance of the differences between the retention scores of the low SA participants for the two treatments

Table 4.12 shows the results, the difference between the means (8.357 & 8.000) was not significant

Table 4.12

**Unpaired t-Test, exp./imp.
retention test scores
for low SA participants**

		DF	Unpaired t Value	Prob (1-tail)
		34	391	3493

Group	Count	Mean	Std Dev	Std Error
Explicit	14	8.357	2.763	.738
Implicit	22	8.000	2.619	.558

High Spatial Ability- Post-Test

The immediate comprehension post-test scores of the high spatial ability group for both levels of treatment variable, are presented in table 4.13. The difference between the means (11.391 vs 11.167) was not significant ($t = 35, 51$ degrees of freedom)

Table 4.13

Unpaired T-test,exp./imp. immediate test scores for high Spatial Ability Participants

DF	Unpaired t Value	Prob (1-tail)
51	38	3527

Group	Count	Mean	Std Dev	Std Error
Explicit	23	11 391	2 35	49
Implicit	30	11 167	1 949	356

High Spatial Ability- Retention Test

The retention test scores for high spatial ability participants were expected to show a difference in favour of the Implicit treatment. A one-tailed t-test (t= 3 518, degrees of freedom 43) showed a significant difference between the means (11 938 & 9 069) in favour of the Explicit treatment, as shown in table 4 14 below

Table 4.14

Unpaired t-Test, exp./imp. retention test scores for high SA participants

DF	Unpaired t Value	Prob (2-tail)
43	3 518	001

Group	Count	Mean	Std Dev	Std Error
Explicit	16	11 938	2 016	504
Implicit	29	9 069	2 89	537

Correlation Analysis

The relationships between test scores and spatial ability scores were examined using Pearson Correlation Coefficients. Table 4.15 shows the covariance, the 'test score versus spatial score' correlation coefficients (r) and the value of r squared, for the control group and each of the treatment groups.

There are significant correlations between spatial ability and immediate test scores for both treatment groups ($r_{\text{exp}} = .47$, $r_{\text{imp}} = .51$, r -critical for $n=80$ is $.18$). The correlation is higher for the implicit version of the instructional programme. Using the procedure to measure the significance of the difference between two correlation coefficients (Weinberg & Goldberg, 1979), it can be shown that this difference was not significant ($z = .303$, z -crit 1.64).

The coefficients ($r_{\text{exp}} = .52$, $r_{\text{imp}} = .234$) for retention test scores and spatial ability are significant. The correlation between spatial ability and the retention score for the explicit treatment group is much higher than that for the implicit treatment group. The difference between the two correlation coefficients is significant ($z = 2.7$, z -crit $= 1.64$).

Table 4.15

**Correlation Coefficients between Test Scores and
Spatial Ability**

		Count	Covariance	Correlation	R-squared
Immediate Post-test	control group	34	6 393	38*	15
	explicit group	38	18 492	52*	27
	implicit group	71	13 169	51*	26
Retention Test	explicit group	38	18 492	52*	27
	implicit group	67	6 709	23*	055

* significant at 05 level

Chapter Five -Discussion, Conclusion and Recommendations.

Discussion and Conclusions

Introduction

The purpose of this study was to explore the effectiveness of level of explicitness as a variable in the design and production of educational television. The review of the relevant theoretical approaches to learning and instruction via television, highlighted the importance of individual differences in cognitive processing skills. Spatial ability was proposed as a significant moderating variable to the main research question. The problem was then formulated in terms of an aptitude by treatment interaction.

In general, the predicted interaction did not manifest itself. The results show no significant difference between the immediate post-test scores of the explicit and the implicit treatment groups, this holds true regardless of the students spatial ability. The results did show a significant difference between the retention test scores of the two treatment groups in favour of the explicit treatment. An analysis of the retention test scores in terms of the learner's spatial ability, showed the source of this difference to come almost entirely from the high spatial ability group. There were no significant differences between the retention test scores of the low spatial ability group for both treatment levels.

Two measures of learning were taken, an immediate and a delayed post-test. The test items were the same in both cases, consisting of a sixteen item, multiple choice, visual comprehension test. The control group did not receive any relevant instruction, the post-test was administered to this group only once, in order to determine the base level of prior knowledge. All of the treatment groups scored significantly higher than the control group on the immediate post-test and on the delayed test. This verified that learning, as measured by the post-test, resulted from the participants viewing the treatment programmes.

Tests were also carried out to verify that spatial ability was normally distributed between the groups, an analysis of variance of the spatial scores for the two treatment levels and the control group, showed no significant differences.

Discussion

A re-examination of the original hypothesis in the light of the experimental findings, follows

When a television presentation is used to teach visual concepts and principles by means of large group instruction to fifteen year old Irish school children, an aptitude by treatment interaction between the participants spatial ability and the level of explicitness of the treatment will be found. The interaction will be of the following form

students of low spatial ability will benefit more from an explicit version of the treatment than from an implicit version of the treatment

students of high spatial ability will benefit more from an implicit version of the treatment than from an explicit version of the treatment

Immediate Post-test

The results of the immediate post-test fail to validate the hypothesis no aptitude treatment interaction was found and there were no significant differences between the means of the two treatment groups. However, the results did show a strong and significant correlation between the learners spatial ability and the test scores. Participants of high spatial ability consistently out-performed their lower spatial ability counterparts.

The Role of Spatial Ability

The finding that spatial ability was such a good predictor of success in the comprehension test is important. It can be interpreted as verifying that the learners spatial skills are utilized in either learning of the instructional material, or in recalling and applying it to the test situation, or both.

One way of finding out whether these effects were due to the treatment conditions and not the testing conditions was to examine the correlation coefficients for the treatment and control group's test scores and spatial ability. Table 4.15 shows the spatial ability correlation coefficients for all of the post-tests. There was a significant correlation between spatial ability and comprehension test scores for the control group. However, this correlation was less than that of the treatment groups ($r_{\text{control}} = .387$, $r_{\text{exp}} = .52$, $r_{\text{imp}} = .51$).

The square of r multiplied by 100 provides an estimate of the amount of common variance (Tuckman,1978) The spatial ability of the control group accounted for approximately 15% of the variance of their post-test scores However, the spatial ability of the treatment groups accounted for approximately 27% of the variance of their test scores This increase (12%) accounts for the influence of spatial ability on the encoding, storage and retrieval processes of the treatment groups

The Treatments

The reasons why the immediate comprehension test failed to detect any differences between the performance of the two treatment groups also need to be explored The comprehension test was administered immediately after the treatments The type of learning it measured was short-term recall and application of concepts and principles

One possibility is that the difference between the level of explicitness of the two treatments may have been too small to matter for this type of learning and the test results merely reflect this It is also possible that the relationship between spatial ability and explicitness (as defined in this study) is weak Salomon's (1979) preferential compensation hypotheses proposed that media symbolic codes could compensate for a learners deficient mental processing skills In this study it was hypothesized that the instructional stimuli would require that the learner use his or her spatial skills to process the information However, the aspects of

the presentation that were manipulated to form the two treatment levels, may not have been relevant to spatial skills

A similar result is reported by Carrier and Clark (1978), they found only a weak relationship between spatial ability and spatially oriented treatments. They speculated that the participants may have used other strategies, for example verbally competent students may have used verbal reasoning on some of the spatial tasks. This would account for low spatial ability participants performing equally well on both the explicit and implicit treatments.

Many theorists (for example, Cattell, 1971, Snow and Lohman, 1984, p 360) emphasize the 'fluidity' of cognitive skills. Snow and Lohman describe the categories of cognitive aptitudes in terms of Gc crystalized ability, Gv verbal ability, and Gf fluid ability.

"Gc and Gv tasks differ primarily in the kinds of knowledge and skill components they sample, the former stress more the digital sequential processing of verbal symbolic information, whereas the latter involve more analogic-parallel processing of figural spatial information. Gf tasks require the flexible adaptation of either of these kinds of assemblies, and their integration in complex performance."

Spatial ability may not have been the most appropriate aptitude measure for this learning situation. The DAT space relations test is obviously a test of Gv. However, the implicit treatment may well have called upon the learners Gf as well as Gv abilities. The data provides no measure of Gf and the confounding effects of this variable cannot be evaluated.

Snow and Lohman (1984, p 360) recommend an alternative research strategy for measuring aptitude effects

"For the purposes of analysis, at least, ATI research and much of the research on aptitude and learning is best served by defining a G or G₁ first principle component and then distinguishing the G_c G_v contrast "

The Delayed Test

A difference between the two treatment levels in favour of the explicit treatment was detected by the delayed post-test, this difference was also shown to be originating from the higher spatial ability participants. Students of high spatial aptitude significantly out-performed their lower spatial ability counterparts. Students who received the explicit version of the treatment and who had a high level of spatial ability, were the optimum achievers in this test. The test scores showed no significant difference between the treatment groups for students of low spatial ability.

The Role of Spatial Ability

Once again an analysis of the correlation coefficients for spatial ability and treatment, and spatial ability and control, reveals the extent of the influence of spatial ability on achievement. The correlation coefficients for the respective treatment groups ($r_{\text{exp}} = .52$, $r_{\text{imp}} = .23$) show a significant difference in favour of the explicit treatment. Comparisons with the control group ($r_{\text{control}} = .38$) confirm the influence of spatial ability on the explicit treatment group's scores and its lack of influence on the implicit treatment group's scores.




The Treatments

The hypothesis proposed that the explicit version of the treatment would benefit the low spatial ability group in that the moving sequences would model the internal manipulation required during processing. It was also expected that this explicit manipulation would interfere with and hinder learning for students of high spatial ability. The results showed a general trend that the explicit version of the treatment benefited both high and low spatial ability groups.

There was no significant difference in the delayed test performance of the low-spatial-implicit group and the low-spatial-explicit group. The possible explanations for this have been outlined above, the differences between the treatments may have been too small to matter for this type of learning or the learners may have used alternative strategies to process the implicit version of the treatment and thereby compensate for its lack of visual explicitness.

The reasons why the high-spatial-explicit group performed better than the high-spatial-implicit group, need to be discussed. The immediate comprehension test failed to show any significant difference between the performance of these two groups, and yet, the same test delivered three weeks later shows good retention for the high-spatial-explicit group and significantly poorer retention for the high-spatial-implicit group. Similar results, where treatment effects are different for immediate and delayed post-tests, have been reported elsewhere. Dwyer, C (1986) reports



different treatment effects for immediate and delayed tests of visual learning Dwyer and Melo, (1983, pp 107-108) reporting on their study of the effects of visual testing in assessing the instructional potential of variables associated with visualized instruction, comment

"a very significant characteristic of visual testing was revealed in this study, -it's sensitivity in assessing delayed retention of visualized instruction in different cognitive levels (criterion test levels) and interactions among visual instructional variables that were not revealed on the immediate visual testing situation and were not detected in any way by the nonvisual test "

The explicit treatment obviously better facilitated long-term retention of the material than the implicit treatment Why was this so? Learning theories, reviewed in chapter one, point to a two structure memory system The short-term, working or active memory, characterized by a limited capacity and rapid information decay, and the long-term memory, characterized by a much greater storage capacity and more permanent maintenance of information Data manipulation and processing takes place within the short-term memory , however many studies have pointed to the limited capacity of this memory (Travers, 1982) Craik and Lockhart (1972) maintain that the extent and 'depth' of the mental processing that takes place in the working memory during the learning situation will determine it's effectiveness Salomon (1984, p 648) describes mental elaborations as ranging from automatic and effortless

stimulus-dominated processes to the more effort demanding and controlled ones. He continues

"it is the latter rather than the former processes that lead the material elaborated on to make contact with other mental schemata, thus to leave more memory traces and to enrich meanings arrived at"

Presumably, it was the explicit and not the implicit version of the treatment which activated these latter 'effort demanding' processes. Studies investigating instructional techniques designed to facilitate long-term rather than short-term memory have indicated that more meaningful tasks result in better retention of stimuli (Bovy, 1981). The explicit version of the treatment may have presented the stimulus material in a more meaningful way. The externally manipulated visuals would have relieved the workload of the short-term memory and thereby facilitate deeper and more meaningful processing to the long-term memory store. Alternatively, the implicit version of the treatment required that the learner must constantly internally manipulate (using spatial skills) the images in order to interpret the stimuli. The limited capacity of the working memory would prohibit any deeper and more meaningful processing. This would facilitate short-term and not long-term retention. This model also accounts for the influence of spatial ability, the high-spatial-implicit group performed as well as the high-spatial-explicit group on the immediate post-test but failed to replicate this on the delayed test.

Conclusions and Applications

This study has provided a number of conclusions that have implications for instructional designers, producers of educational television and educational technology theorists

Firstly, the role of spatial ability as a significant variable in visual concept learning from television has been emphasized. The correlation between achievement on the criterion post-tests and the space relations pretest reinforces the growing movement toward greater recognition of individual differences in cognitive abilities when designing instruction. In particular, where television is used because of its communications capabilities, as a vehicle for mass instruction, the moderating effects of individual differences need to be allowed for.

Secondly, the use of television to teach visual concepts and processes has been shown to be effective. The treatment groups performed significantly better than the control group on the criterion tests. Most of the participants were able to demonstrate that they could apply more than 50% of the learned concepts and principles three weeks after viewing the programme.

Thirdly, the differential effects of explicit movement and manipulation as an instructional television variable have been shown. Producers of educational television should be mindful of the fact that the two treatment levels used in this study differed substantially in terms of the time and resources needed for their production. However, testing of

the total sample revealed no significant differences between the performance of the two treatment groups on the immediate post-test. Only the high spatial ability students benefited in the long term from the explicit version of the treatment. The study may be interpreted as cautiously supporting the use of movement, animation and freeze-dissolve sequences to teach visual concepts through television. The importance of the match between the instructional task and the learners cognitive skills has also been emphasized. It is only when all of these interacting elements are taken into account, that the full instructional potential of educational television can be realized.

A fourth conclusion that can be drawn from this study is the importance of delayed visual testing. No treatment effects were evident from the immediate post-test. The delayed test, administered three weeks after the treatment showed significant differences between the explicit and implicit treatment groups. Most learning goals are directed toward long term retention, immediate post-tests, administered only minutes after the treatment may not always be the most appropriate measure of learning.

Recommendations for Further Research

The correlational analysis of this study revealed the significance of spatial ability, as measured by the DAT Space Relations test, on the instructional situation. In the light of the experimental results a replication of the experiment using other measures of ability should be attempted. A

measure of general fluid ability (Snow and Lohman, 1984) such as Raven's (1983) Standard Progressive Matrices might be suitable, this may provide a more reliable indicator of the learners existing cognitive processing capabilities

The match between these capabilities and the compensatory function of the modelling condition of the treatment, is crucial for the generation of meaningful aptitude by treatment interactions Carrier and Clark (1978, p 335) suggest

"One solution may be to lay out all the critical steps necessary to task completion using a procedure similar to task analysis, which results in a hierarchical configuration "

The dilemma for experimenters is that real learning situations involve numerous tasks, capable of being accomplished by any number of cognitive abilities

This study was concerned with visual concept and principle learning, an extension of this line of research to include other forms of learning is recommended The predominance of verbal learning and testing in schools and universities would imply that replication studies examining the effects of the television explicitness variable for learning of nonvisual concepts and principles, would have a wider relevance The effectiveness visuals used to compliment oral and verbal instruction has been the subject of extensive research In an extensive review of experiments on this topic Levie and Lentz (1982) proposed that illustrations can function to facilitate learning of textual

information by enhancing both comprehension and retention
How this comprehension and retention is effected by the level
of explicitness of television treatments, would be a relevant
research question

Studies have indicated a relationship between
intellectual development and ability to process visual and
verbal information (Randhawa,1971) A study by Owens
(1988) has shown that personological variables such as age
and level of education affect cognitive learning from
television The participants in this study were 15 year old
Irish schoolchildren, replication studies for other age groups
and population samples are recommended

Studies from the Programme of Systematic Evaluation
(Dwyer,1987) have shown how variations of the same
stimulus elements and criterion measures could be used to
investigate the multiplicity of variables associated with
visual learning The stimuli and criterion tests developed for
this study examined only one aspect of a complex learning
situation Replication studies, manipulating other production
variables, using the same set of learning stimuli, would
contribute to a greater understanding of the problem of
learning from television

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Appendix A

The instructional treatment

"Making the Most of the Sun"

duration 15 minutes

Notes 1 The two version of the programme were identical in every respect except for the graphical sequences depicting the target concepts and processes. These are numbered 1 to 13 in the script. A brief note of the differences between the explicit and the implicit versions is provided at the relevant points.

2 The following notations are used, PTC for piece to camera, CU for close up shot, WS for wide shot, MCU for medium shot.

Seq. no.	Visuals	Sound
1	Rapid attention getting sequence showing solar panels light reflections etc	Music
2	Text Graphic Making the most of the Sun	
3	Presenter to camera (PTC) Studio setting, blue background with gobo light to suggest the Sun	This programme is about solar energy, that is energy derived directly from the Sun.
4	Presenter refers to light source	
5	coal fire	Almost all of the energy available to us here on earth has come from the Sun at some stage. This may not be immediately obvious but if you think about it you'll see why it is true. You could say that we get energy by burning turf, coal or other fossil
6	power station	fuels. Heat can be generated using these fuels, heat that can be used to generate electricity or to warm our houses. However turf and coal
7	Close up (CU) of turf, dissolves to trees and bogs	and the other fossil fuels were once a dense vegetation that covered the landscape.
	Medium close up (MCU) of sunlight on leaves of trees	When this vegetation was alive, it grew by using the energy from the Sun to

Seq. No	Visuals	Sound
8	zoom out to show many trees	<p>convert the nutrients in the soil into the carbon that made up its structure.</p>
9	PTC outside fossil power station	<p>So the furnaces in this power station are re-converting this energy, originally derived from the sun, into electricity to heat the homes of today.</p>
10	Chimney stacks of peat power station possible shot of milled turf on conveyor belt	<p>In Ireland most of the electricity that we use today has been generated by burning fossil fuels - coal, peat, oil or natural gas - all of these were made at some stage using the energy of the Sun.</p>
11		<p>Obviously, the amount of fossil fuels available on Earth is not limitless, at some stage we will run out of these fossil fuels and new forms of energy production will have to be found.</p>
12	Keyed background perhaps slides of Solar Power installations	<p>Today, scientists are investigating various sources of energy to replace fossil fuels.</p> <p>Solar power - using the heat from the Sun <u>directly</u> to</p>

Seq. no.	Visuals	Sound
13	Clouded skies over a typical Irish countryside	<p>generate electricity is one possibility. But for countries like Ireland that do not have a reliable and continuous supply of sunshine this may not be a good solution.</p>
14	PTC	<p><u>Passive</u> solar heating is a much realistic proposition. Passive solar heating involves designing and constructing buildings to directly capture, store and distribute the energy already available from the sun.</p>
15	Passive solar buildings, features such as skylights, reflective surfaces and bright natural light environments	<p>Passive solar heating can be used to supplement or backup already existing heating systems, it's cheap and its clean and it does not involve using up fossil fuels. Its</p>
16	PTC WS	<p>passive - it does not effect the environment - it simply makes the most of what we already have - the energy from the sun.</p>
17	in studio keyed background houses being built	<p>How can we build our houses and design our homes in such a way as to get the most from the energy of the sun?</p> <p>If we apply some simple</p>

Seq. No	Visuals	Sound
18	WS presenter	<p>scientific principles to where we position our houses and how we build them we can increase the amount of natural energy available for use.</p>
19	CU presenter	<p>What do we mean when we talk about light, heat and solar energy?</p>
20	Graphic depicts em radiation from Sun, different wavelengths	<p>All of the energy that comes to us from the sun comes in the form of electromagnetic radiation. This is made up from radiation of many different wavelengths. Energy whose wavelength lies within the particular band of</p>
21	Graphic to depict the em spectrum with visible band	<p>wavelengths for which our eyes are sensitive, is known as visible light. Our bodies, however, can sense radiation of longer wavelength, beyond that of visible light, this is</p>
22	and infra-red band	<p>infra-red radiation or heat radiation.</p>
23	Graphic HEAT ENERGY to reveal	<p>Heat energy can be transferred in three different ways: radiation, conduction</p>

Seq. no.	Visuals	Sound
24	RADIATION CONDUCTION CONVECTION graphic showing radiated heat presenter shows electric fire	<p>and convection.</p> <p>Radiation, we have already seen. Heat energy is radiated in the form of electromagnetic radiation, examples of radiated heat are: the heat from the sun, and the heat that comes directly from from an electric fire. In fact an electric fire very clearly demonstrates how light and heat come from the one source, when I switch on this fire, first of all I can feel the heat radiation and then I see the red light from the bars.</p>
25	Poker in fire graphic	<p>The second way in which heat energy can be transferred is by conduction, in this case the heat is transferred along some medium known as a heat conductor. Some materials like metals, are good</p>
26	CU red hot metal	<p>conductors of heat. You can feel conducted heat when a</p>

**Seq.
No**

Visuals

Sound

27

wool
gloves on metal handlebars
(graphic)

poker is placed in a hot fire. Other materials do not conduct heat as easily, these are known as insulators. An example of a good heat insulator is wool, a pair of gloves will prevent the heat from your hands from being conducted along the handlebars of a bicycle on a cold morning. If it rains and the gloves get wet then, because water is a good conductor, the heat from your hands will be conducted away and they will feel cold.

28

No 1
Explicit
air moving around the container, colour code blue for cold air, red for warm air The colour change and the movement take place simultaneously

Implicit
static positions of warm and cold air and then arrows to indicate the direction of the current

The third way which heat energy can be transferred is by convection, what happens is this: air, when it is heated, becomes less dense and lighter and therefore rises, when this happens cold air moves in to replace it - this air in turn becomes warmer and lighter and the process is repeated. A continuous current, known as a convection current is set up, with heat being distributed throughout the space

Seq. no.	Visuals	Sound
29	PTC in studio	<p>available.</p> <p>All of the heat energy that we use comes to us by means of radiation, conduction or convection from a heat source.</p>
30	<p>Presenter walks towards car gets into front seat</p> <p>feels surface</p>	<p>I'm sure that all of you will have experienced this at some time: if you get into a car on a sunny day after the car has been parked in direct sunlight, the inside of the car will feel very warm, much warmer than the air outside. In fact if you feel any of the surfaces just inside the window they'll feel very hot indeed! One of the reasons why this happens is because of the GREENHOUSE EFFECT.</p>
31	text graphic	
32	PTC outside large greenhouse in Botanic Gardens	<p>To illustrate this effect what better place to choose than here, these are the botanic gardens in Glasnevin, Dublin and this great greenhouse here behind me is one hundred and fifty years old.</p>
33		<p>The temperature in here is</p>

Seq. No	Visuals	Sound
34	<p>inside greenhouse</p> <p>No 2</p> <p><i>Explicit</i> waves moving through the glass and are reflected back into enclosure</p> <p><i>Implicit</i> Static Wave inside enclosure, later a longer wavelength static wave "trapped" at roof</p>	<p>twenty degrees centigrade, that is six degrees warmer than the air outside, in this special environment tropical plants, that would not survive in a climate like ours, thrive</p> <p>The greenhouse effect works like this:</p> <p>In its simplest form we have an enclosed space with a glass roof to allow the sunlight through and a surface which can absorb heat energy. Glass is transparent for visible light which we already know is electromagnetic energy of a particular band of wavelengths, it allows these wavelengths to pass through into the enclosed space. The glass is transparent for these bands of electromagnetic radiation. The absorbing surface at the bottom will take in this energy but it will itself begin to radiate heat energy back into the enclosure, this re-radiated energy has a shorter wavelength than the incoming energy and glass is not</p>

Seq. no.	Visuals	Sound
		<p>transparent for these longer wavelengths, the heat energy is trapped inside the enclosure and therefore the temperature increases.</p>
35	PTC Studio	<p>Let us now look at how we can apply our knowledge of the science of heat to the design and construction of energy efficient houses.</p>
36	CU pull to WS houses and trees	<p>Houses using passive solar heating designs.</p>
37	crops in field	<p>First of all we will look at the ways we can site houses and position them relative to the sun. Investigating the site and the micro-climate, that is the local climatic conditions in the area, is an important step in designing a building.</p>
38	trees	<p>In the same way that a farmer will pick the best location for a particular crop, taking into account the amount of sunshine, the prevailing winds and the nature of the plants</p>
39	gardener	<p>or trees next to it, so the person who investigates a</p>

Seq. No	Visuals	Sound
40	outside of house	<p>site for a house must take these things into account.</p> <p>Houses are after all designed for us to live in and like plants we need light and heat and a comfortable environment to live in.</p>
41	<p>No 3</p> <p><i>Explicit</i> <i>Earth and Sun, Nth Hemisphere changes colour and arrow indicates Sun to the South</i></p> <p><i>Implicit</i> <i>Static version of same graphic graphic, Nth and Sth indicated by arrows</i></p>	<p>The position of the sun is one of the first things that needs to be taken into account. We live in the northern hemisphere and therefore the sun is always positioned in the sky to the south, if we lived in the southern hemisphere the sun would be in a northerly position in the sky.</p>
42	House with Sun in Southern Sky	<p>In Ireland if we locate our houses so that the windows face south then we can get the most benefit from the energy of the sun.</p>
43	<p>No 4</p> <p><i>Explicit</i> <i>shows Earth moving from the Summer to Winter angular position</i></p>	<p>There is another feature of the sun which can be taken into account:</p> <p>The earth is inclined at an angle to the sun and during its once a year orbit of the sun we are inclined towards the</p>

Seq. no.	Visuals	Sound
44	<p><i>Implicit same graphic without the gradual movement</i></p> <p><i>No 5</i> <i>Exp Sun animates between high and low position</i> <i>Imp Sun in middle position, arrows indicate direction of movement</i></p>	<p>sun in summer and away from the sun in winter. What this means for us is that the sun appears lower in the southern sky in winter and much higher in the sky in summer.</p> <p>When we look at the effect of this on south facing windows we notice an interesting feature. In winter when we need as much heat as possible, the rays of the sun are such that most of the light and heat will pass directly into the room. In the summer when too much heat can be uncomfortable, the sun's rays come at a much greater angle and therefore are not as effective. In this way south facing windows will regulate themselves, allowing in most energy in the winter when it is needed and the least amount of energy in the summer when it is not needed.</p>
45	<p><i>No 6</i> <i>Exp Summer & Winter rays are shown, animation shows changing angle</i> <i>Imp No rays and no movement Cut between Summer and Winter position</i></p>	<p>Also the shape of the roof can be such that it can shade the room from sun in the summer whilst having no effect in the winter.</p>
46	<p><i>No 7</i> <i>Exp Roof animates to show long South facing overhang, Summer and Winter Sun positions are animated</i> <i>Imp Overhang shown, Sun in</i></p>	

**Seq.
No**

Visuals

Sound

middle position

No 8

Exp Tree dissolves on and blocks Sun's rays tree shown in Summer shading in winter no tree allowing Sun-light through

Deciduous/evergreen comparison mad using dissolves trees shown shedding leaves movement emphasizes summer and winter variations

Imp Straight cuts are used to show summer and winter requirements and to compare tree types Trees shown in position and Sun in middle of sky

Another aspect of the positioning and location of a building that needs to be considered is the nearby vegetation especially trees. Suppose we built a house so that the trees were directly in front of the south facing window, what would be the effect? Well, in the summer we would like the trees to shade the window from the sunlight whilst in the winter we would like as much light as possible to be allowed through. If the trees were deciduous (and they shed their leaves in winter) then they would help to regulate the energy of the sun allowing most energy through when it is most needed in the wintertime. On the other hand evergreen trees would provide shade in the summer but because they would not shed their leaves they would also block the sun in winter.

We can now look at some building design features

47

Seq. no.	Visuals	Sound
48	<p>No 9</p> <p><i>Exp Trombe wall soaks in the moving rays of the Sun glows red and then begins to re-radiate into room At the same time sky slowly changes from day to night sky</i></p>	<p>which can use the energy of the sun efficiently. A room with a south facing window will benefit from the greenhouse effect, just like the glasshouses that we saw earlier. We can maximise this effect by placing an absorbing wall just inside the window. This is known as a Trombe wall after the man who invented it. The wall is designed to soak in the energy during the day and to re-radiate it in the evening and night-time. The wall is dark coloured on its south face, this helps absorption. Later when the wall itself radiates energy it can do so directly into the living space behind it.</p>
49	<p><i>Imp Cuts between day and night Arrow indicates direction of re-radiated energy</i></p> <p>No 10</p> <p><i>Exp An animation sequence shows the energy being radiated and trapped</i></p> <p><i>Imp An arrow indicates the space between the wall and the window</i></p> <p>Picture of actual Trombe wall</p>	<p>Energy is also radiated into the space between the wall and the window and by the greenhouse effect most of this energy is trapped in this space.</p> <p>You may think that this wall will block all the light but it need not cover the entire</p>

Seq. no.	Visuals	Sound
52	PTC in studio	<p>So this is a blueprint for a house that makes the most of passive solar energy</p>
53	<p>No 13 Exp review uses the same animation techniques as before</p> <p>Imp reviewed with static pictures as before</p>	<p>-the south facing windows get most of the suns energy</p> <p>-nearby deciduous trees help regulate the summer and winter requirements</p> <p>-a Trombe wall makes the most of the greenhouse effect</p> <p>-the vents create convection currents which warm the room at night</p> <p>-and the moveable insulator which helps reflect the sunlight during the day.</p>
54	PTC in studio	<p>We have seen how science can work to help us to get the most out of the energy of the sun, when we want it and where we want it. The processes of heat transfer: radiation, conduction and convection can be applied to our benefit to help us to make our houses more comfortable and energy efficient. Passive solar heating is about using science to harness the energy</p>

Seq. No	Visuals	Sound
50	<p>No 11 Exp Convection current is shown moving with cold air indicated as blue and warm air red</p> <p>Imp Static version of the same graphic with arrows to show the vents</p>	<p>window surface and architects can position them in the best places.</p> <p>A very clever addition to this design is the insertion of two convection vents, one at the bottom and one at the top of the wall. The result is that a convection current is established, cold air entering the space is heated by the radiated energy, it rises to the top where it exits as a current of warm air into the living space.</p>
51	<p>No 12 Exp Insulation is animated between day and night position Sun's rays are seen to reflect off the reflection surface</p> <p>Imp No animation used just day and night positions Angle of reflection is indicated by an arrow</p>	<p>A further way of improving this system is to add an insulation surface against the outside of the window so that even less heat energy can escape through the window into the cold night-time air. Of course this insulation would have to be removed in the daytime. If it were hinged at the bottom and the inside surface was made of reflective material it could even add to the amount of energy entering the room during the day.</p>

**Seq.
No**

Visuals

Sound

55

End Picture

of sun. Today, there are only a few buildings which are designed for passive solar heating. But in the future as our energy needs continue to grow and the availability of fossil fuels decreases designs that make the most of the sun will no doubt be an important feature of every home.

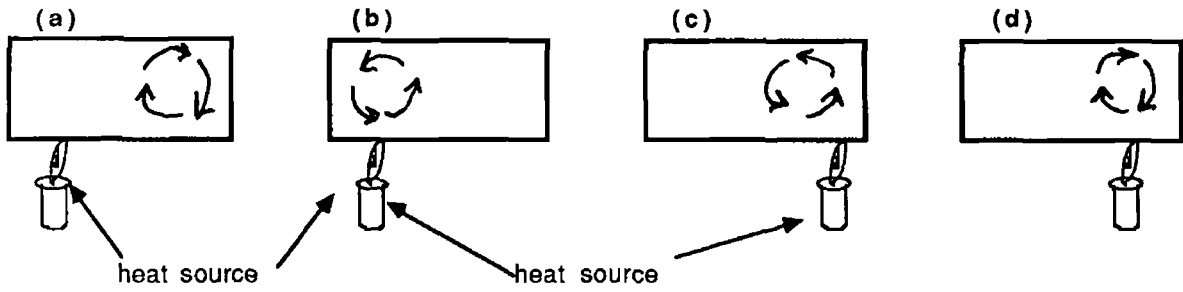
music

Appendix B

The Post-Test

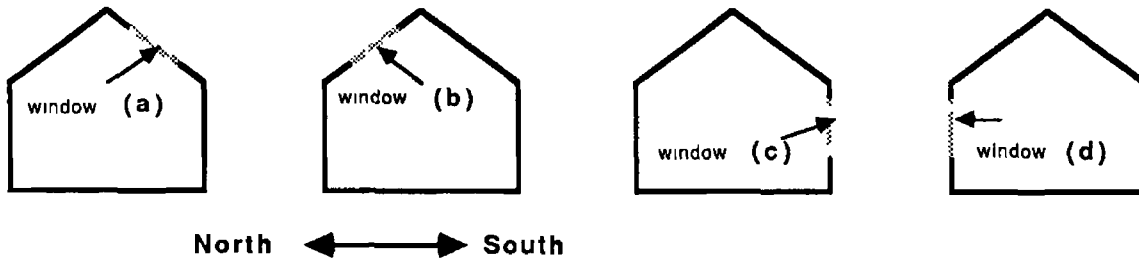
time allowed approximately, 12 minutes

(1) Which of the following diagrams represents a convection current?



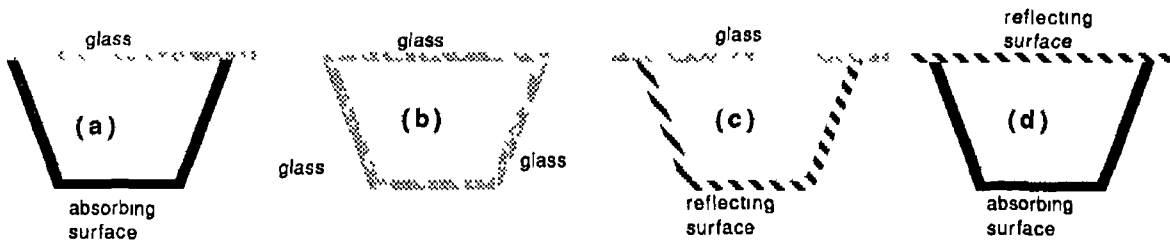
answer

(2) These houses are in Ireland on a sunny day in winter, which window will get the most energy from the sun?



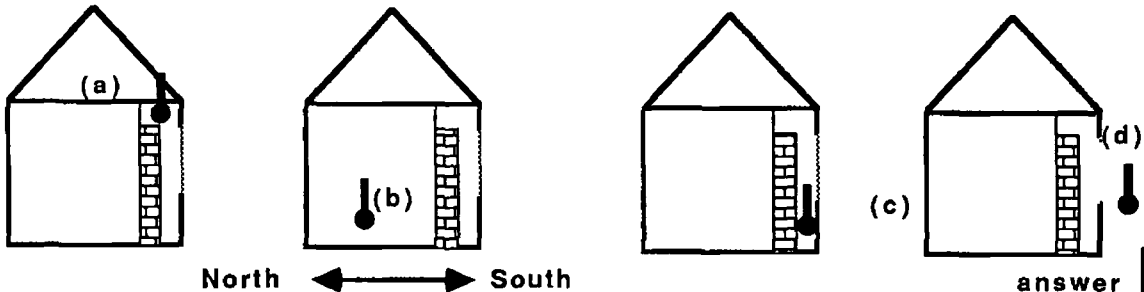
answer

(3) Which of the water containers will heat up quickest in direct sunlight by the greenhouse effect?



answer

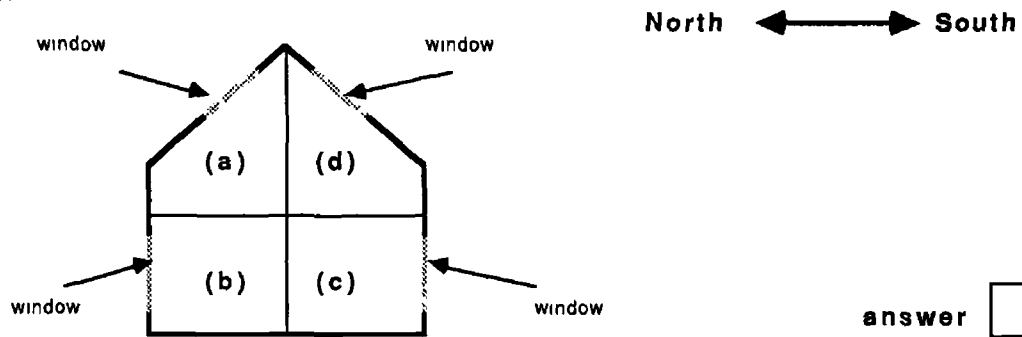
(4) These houses are in Ireland. It's night, after a long sunny day, which thermometer would you expect to read the highest temperature?



answer

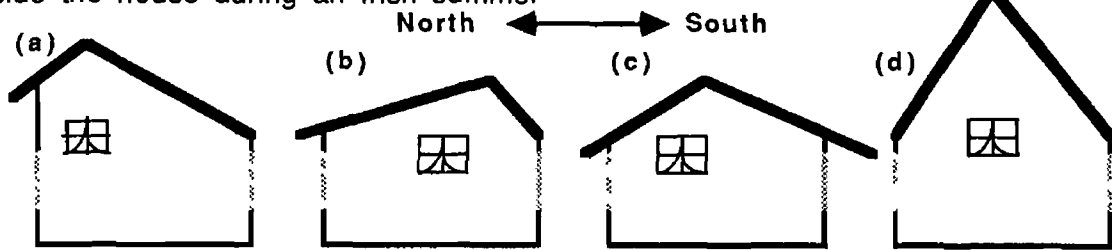
Name _____
Class _____

(5) It's summertime in Ireland, which room will heat up most from the sun?



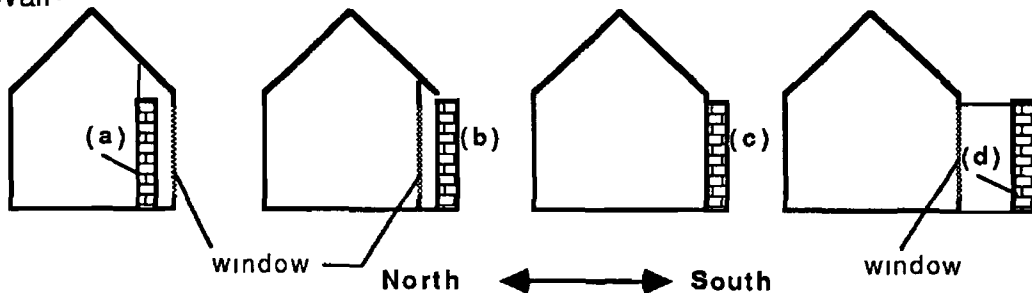
answer

(6) Which of the following roof designs will provide most shade inside the house during an Irish summer?



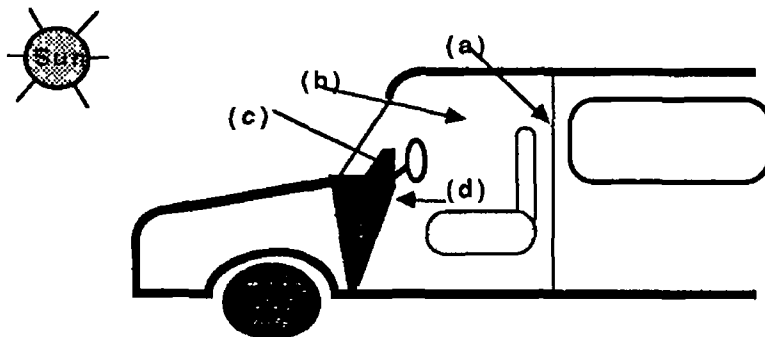
answer

(7) Which one of these walls is known as a Trombe Wall?



answer

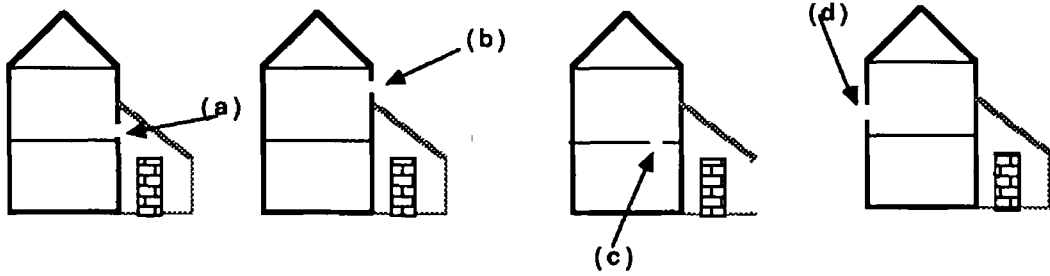
(8) Which part of the van will heat up quickest in the direct sunlight?



answer

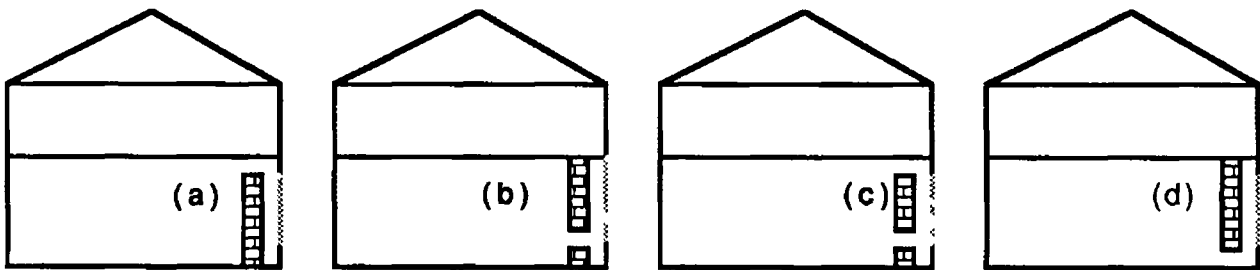
Name _____
Class _____

(9) Where would you place the convection vent so as to heat the upstairs bedroom?



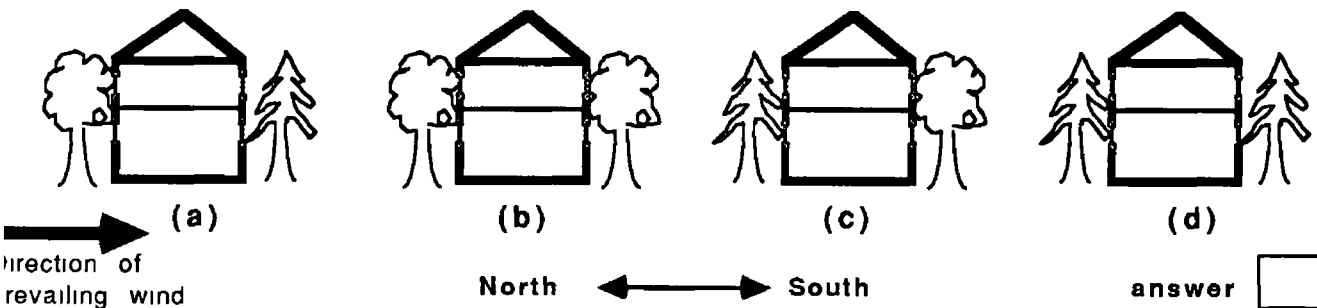
answer

(10) Which Trombe wall design will heat the downstairs room at night by convection?



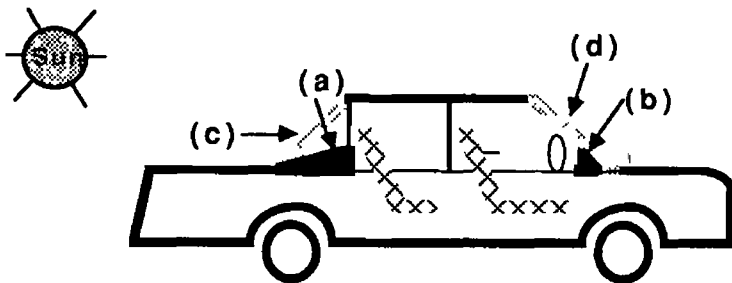
answer

(11) These houses are in Ireland. Which arrangement of trees is best suited to give good solar heating in winter and protection from the prevailing wind?



answer

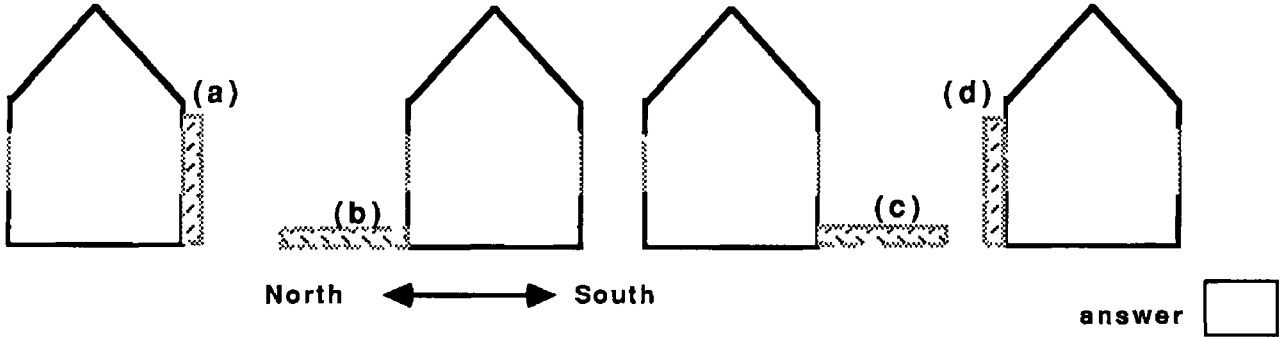
(12) Which part of this car will heat up by the greenhouse effect?



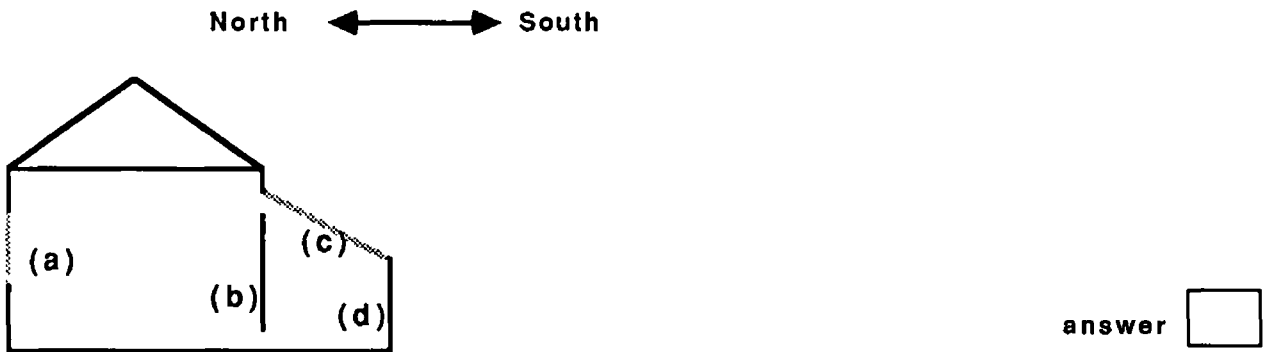
answer

Name _____
Class _____

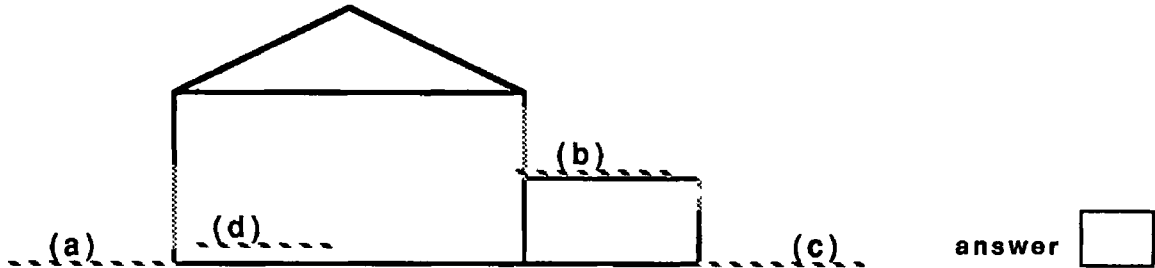
(13) This house is in the Southern Hemisphere and it uses a Trombe wall for passive solar heating. Which is the best position for the moveable insulation surface at night?



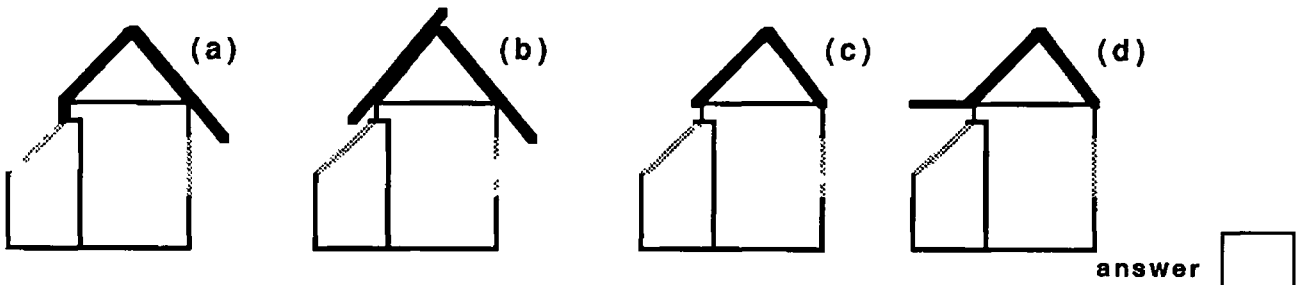
(14) This house is in the Southern Hemisphere. Where would you locate a Trombe wall?



(15) This house is in Ireland. Where would you locate a reflective surface so as to increase the amount of energy entering the house from the sun?



(16) These houses are in the southern hemisphere. What is the best roof design for internal shading during the summer?



Name _____
 Class _____