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A comparative analysis of lectures versus interactive computer-assisted learning packages for the teaching and learning of anatomy by tertiary students

by

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ABSTRACT

The primary aim of this study was to validate interactive computer-assisted learning packages (ICALP) in a self operated computer controlled educational resource (SOCCER) to undergraduate (UG) physiotherapy students of anatomy. The development of ICALP, Test and FeedBack Items for SOCCER are described, as well as the mechanism of delivery with continuous positive reinforcement to randomly selected students. To meet this requirement, a computer managed learning environment (CMLE) was established to affirm the value of ICALP and SOCCER materials to replace traditional lectures in anatomy. Quantitative data is given to verify this hypothesis during the education of UG physiotherapy students of anatomy. Throughout 1992, the UG population was randomly divided into Lecture and ICALP groups, with mutual exclusion of each to the other, for ten areas of study. These results were validated by re-application to the succeeding UG population in 1993. The secondary aim of this study was in two-parts. Firstly, to verify that ICALP materials can be applied to transfer 2-D cognitive anatomical information in a self-paced format of autonomous learning. Secondly, to investigate a premise that previously acquired 2-D anatomical information may be transferred into a 3-D psycho-motor skill. Ample data is given to verify the first hypothesis, with sufficient evidence to support the second. The subsidiary aim of this study compared the educational and administrative cost-effectiveness of ICALP and SOCCER with traditional lectures used in anatomy. Evidence is given to demonstrate that the time saved in lectures can be replaced by a lecture-seminar approach to problem-based learning to empower UG2 students to achieve at a level beyond that which would normally be expected. Sufficient data is provided to affirm the cost-benefits of ICALP and SOCCER to academic staff, individual students, and administrators. The untested belief held by schools of anatomy that high ranking pre-entrants in English, English Literature, and Human Biology, are more likely to transpose 2-D anatomical information into a 3-D skill than high ranking pre-entrants in Mathematics, Chemistry and Physics was also investigated. Scrutiny of these data could not determine any discriminatory differences of ability to succeed in UG anatomy by either of these two categories.
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CHAPTER 1

THE PROBLEM AND ITS BACKGROUND

Anatomy is an extremely visual science, requiring a well-disciplined form of delivery for the concise presentation of detailed images by use of careful and clear description, supported by slides and over-head projection. By convention, the delivery of complex anatomical information to students at the tertiary level is by lecture, reinforced by supervised laboratory investigation and practice. The inherent weakness of the delivery of core information by lecture to large groups of students lies in the constraints of its environment. Irrespective of the quality and skill of the lecturer, the effectiveness of the outcome is determined by the vagaries of the lecture situation and the ability of its audience to sustain a high rate of concentration throughout periods of up to two hours. The mere geography of a lecture environment may not be conducive to attentive learning by its audience. An effective lecture requires inspirational content, developed in a challenging atmosphere to stimulate the various learning styles of its audience. This is a tall order, which is unlikely to reach all members of a lecture group on all occasions. In some cases students may be inspired by the challenge and content of lectures in anatomy, but invariably there are times when such lectures are perceived as dull by the majority of students in a group. Furthermore, the heavy use of graphic-projection devices requires dimmed lighting, which, despite the level of concentration attained by highly motivated students, generally reduces the impact of apparent visual engagement between the lecturer and students, at the same time offering cover, or distraction to students who are not fully committed to the subject. These disadvantages may be
further compounded by the necessary seating arrangements of a large lecture theatre, those at the back and sides not being able to see and hear important concepts being developed, or able to enter into any discussion about important questions which may arise.

Therefore, this project was commenced to find alternative methods for the presentation of anatomical information in a more challenging and cost-effective environment to meet the multivariate styles of learning within its student body.

To meet this challenge, the exponential growth and availability of computer driven software was investigated to supplement, or displace traditional lectures in anatomy. At an intuitive and empirical level, the educational value of computerized learning techniques is self-evident, although some concerns have been raised about the validity of these techniques. With the advent of sophisticated user-friendly hardware and software devices, on face value it seems likely that these concerns can be safely set aside. However, to do so denies the coincidental evolution of modern educational theory and its effective integration with hypermedia and multimedia. A close investigation of the literature demonstrates a clear need for continual vigilance by carefully controlled parallel experiments to validate the appropriate use of interactive computer-assisted learning packages (ICALP) before they can be used to displace well-entrenched methods.

The primary aim of this study is to quantitatively investigate the hypothesis that ICALP techniques can be as effective as traditional methods when used to teach anatomy to physiotherapy students. The defects of visual images presented in a lecture situation may be
immediately overcome by a personalized presentation of the same images on a computer screen, which can be manipulated by the user in a self-paced environment designed to stimulate a variety of learning styles and record all activities whilst doing so.

The secondary aim of this study will identify the learning processes associated with ICALP materials during the acquisition and transfer of 2-D (two-dimensional) cognitive anatomical knowledge to its integration as a 3-D (three dimensional) psycho-motor skill.

The subsidiary aim of this study will review accumulated data to compare the educational and administrative cost-effectiveness of ICALP techniques for comparison with traditional methods used for teaching and learning anatomy at the tertiary level.

1.1 Research questions
To resolve these problems, this study is focused upon one primary and two secondary research questions, with a subsidiary question divided into three parts concerning cost-effectiveness.

1.2 The primary research question:

Can ICALP materials be effectively used to replace traditional methods when teaching anatomy to physiotherapy students?

1.3 Secondary research questions:

Can ICALP materials be used effectively to initiate the acquisition of 2-D cognitive anatomical information?

Can ICALP materials be used instead of lectures to transfer 2-D information into an effective 3-D anatomical skill?
1.4 Subsidiary research questions:

*When objectively compared with traditional methods, what is the relative cost-effectiveness of ICALP materials to:*

- **a:** Academic staff-members
- **b:** Individual students
- **c:** Administrators

1.5 Methods used to answer these research questions

To answer these research questions the following procedure was devised.

**a:** A comprehensive literature review was undertaken to look at the general development and application of computer-based learning (CBL) over the past three decades. This review not only targeted the application of CBL related to the healthcare professions, but was also directed at its specific use for learning anatomy at the tertiary level. This literature review focused on studies to investigate matters related to its cost-effectiveness.

**b:** The anatomy curriculum at the School of Physiotherapy, Curtin University of Technology, was used to compare and evaluate data acquired from learning by traditional lectures with that from ICALP materials.

**c:** The curriculum was reformulated to contain ten discrete areas of anatomy that were simultaneously presented to those learning by traditional lectures for comparison with those learning the same materials by ICALP.
d: First and second year students of anatomy in the physiotherapy program were randomly subdivided into either lecture or computer-assisted learning groups.

e: The same test items were applied to both groups, at pre-, post, and re-test intervals. These tests were unexpectedly re-applied at 60 and 120 day intervals to quantitatively compare the level of recall of both groups in neuroanatomy.

f: To measure learner reactions to these techniques a computerized FeedBack Instrument (FBI) was developed and applied.

g: Steps (c) through to (f) were repeated on a subsequent cohort in 1993 to validate the results obtained in 1992.
CHAPTER 2

REVIEW OF THE LITERATURE

2.1 An approach to autonomous learning

Reflective analysis is considered to have originated from eminent Greek Philosophers in about 600 B.C. According to Avey (1961) and Guthrie (1967), this period was dominated by abstract philosophies which gave rise to generalisations about the universe and the science of mathematics. These philosophies evolved into the epistemology of education by fusion of the influences of Socrates, Plato and Aristotle (Avey, 1961; Copi, 1968; Cornford, 1941; Guthrie, 1967; McMaster, 1973; Ross, 1955; Watson, 1963).

Socrates (469-399 B.C.) is probably best known for his view that 'virtue is knowledge', which he directed towards an improvement of human life at the grass-roots (Avey, 1961; Guthrie, 1967). According to Avey, the Socratic style of dialectic discourse was designed to facilitate learning by the use of unanswered open ended questions to clarify concepts by clearing away the untenable. With a passionate belief that knowledge is possible, the Socratic method of teaching may be used to engage the mind of the members of an audience to remove the debris of ill conceived thought before the search for it may begin (Guthrie, 1967; McMaster, 1973).

Aristotle is renowned for exploration of the process of inductive reasoning, where a major premise is established, preceded by discussion from the known to the unknown. Aristotle extended inductive reasoning into intuitive reasoning to grasp the ultimate
principle of a particular concept. In this way, Aristotle carried the beliefs and teachings of Socrates and Plato to develop the reasoning styles of inductive and intuitive reasoning into the formulation of *syllogisms* (Avey, 1961). Aristotelian syllogisms are arguments which differ from Socratic dialectic, from which a conclusion is drawn from two sides of a debate in which more than one premise is expressed (Copi, 1968). Kidd (1959), referred to Aristotelian philosophers as a group distinguished by its emphasis upon learning in adults.

From this brief discourse of the dialectic style of Socrates, the inductive reasoning of Plato and the formulation of Aristotelian logic, it is feasible to observe that the problem-based learning methods enunciated by Kohler (1925) are derived from the Classical Period of education, which commenced more than 2,500 years ago.

Although further discourse into the originations of educational theories about learning would seem inappropriate to this thesis, such theories are still applicable to the field of modern health science education. During the development of computer-based learning instruments for this project, a Socratic style of questioning was applied in combination with Aristotelian logic to engender an autonomous life-long learning among its users to cope with an exponential growth of information beyond the means of conventional resources (Barrows, 1983, 1986, & 1988; Barrows & Tamblyn, 1980; Bates, 1994; Birch, 1986; Booth, 1994; Boud & Felletti, 1991; Clark, 1992; Dean, 1989; Khoo & Kingsland, 1994; Lambert, 1992; Lee, 1994; Reeves, 1992; Ring, 1994; Stevens, 1989; Reeves, 1992; Romiszowski, 1992).
2.2 Behaviourist educational psychology

In the early to middle period of the twentieth century, the established philosophical principles of education were applied to investigate human behaviour on a rigidly scientific basis. Thus, the principles of education were adapted by behaviourists to investigate the processes of learning (Shermis, 1967). These investigators became known as behaviouristic psychologists, namely, Thorndike (1911 & 1932), Adams (1929), Watson (1930), and Skinner (1948), all of whom applied the conditioning techniques attributed to Pavlov (1927).

The assumption surrounding education by conditioning is that human beings are considered to be similar to machines. Therefore, like machines, the behaviour of human beings can be explained by mechanical laws (Shermis, 1967). The earliest of the behaviourist group of educational psychologists was Thorndike (1911), who installed cats in a puzzle box to assess the number of seconds taken to escape. Thorndike was able to show, that with practice, the animal was able to decrease the time taken to escape. Furthermore, the typical slope shown on the graphs became known as the learning curve. From these results, Thorndike not only hypothesised a gradual strengthening of connection in which the puzzle box provided a stimulus to learning in the process of escape, but also enunciated the basis of learning is an association between sense impressions and impulses to action. Although the mechanistic aspect of Thorndike's theory may be distasteful, these experiments led to the formulate a theory of learning by the association of ideas which may be applied to the field of computer-based learning (CBL).
These views were influenced by the work of educational psychologists such as Gates (1917), who observed the value of recitation and variations of time allotment applied to experimental and control groups in classroom learning, and the Russian physiologist, Pavlov (1927), who refined the manipulation of an experimental environment in which dogs were conditioned to associate the sound of a buzzer with the presentation of food.

In human terms, behaviourist psychologists may be exemplified by Kientzle (1946), who verified how behaviour may be varied by the circumstances under which it takes place. One of the most extensive of Kientzle's experiments involved the performance of subjects who were required to rapidly print the alphabet upside down. These experiments ranged around a series of one-minute trials which were either continuous or separated by rests, with a variation between three seconds to several days. Recorded data was presented in graphic form, to observe that increasing rest intervals may prove beneficial up to a given point, followed by a period of diminishing returns. From these data, Kientzle determined that massed practice (cramming) interferes with the quality of performance when learning.

Coincidental to the work of Kientzle were the efforts of Harlow (1949, 1950) and Skinner (1948; 1968). Harlow investigated discrimination sets of learning by monkeys when manipulating objects placed on a tray within reach. During these manoeuvres, close observation was kept of the monkeys' behaviour through a one-way vision screen. Harlow interpreted these results as learning-to-learn by correction of error tendencies. Skinner presented a Pavlovian model of operant conditioned learning in humans, sometimes referred to as instrumental
learning, to shape behaviour by using programmed learning in an environment of conditioned response on a voluntary basis. Skinner's model entailed the construction of teaching machines designed to identify solutions reinforced by operant feedback from the student. In these studies, Skinner (1973) used positive reinforcement as a reward for desirable behaviour to avoid leaving an individual with feelings of being controlled or coerced. From these observations Skinner asserts that individual behaviour is determined, or shaped, by the operation of environmental systems which contain reward and reinforcement (Harvey & Brown, 1976).

2.3 Learning and memory
Although a precise theory of learning is rarely required to be understood by the learner, knowledge of its theoretical base is of prime importance to educators. In classical experiments, Miller (1956) defined the capacity of human memory by the length of time it may be stored on a short, or long term basis. Miller observed that large amounts of information may be stored at deeper levels by 'chunking' before consignment to long term memory.

An essential requirement for learning is motivation. Without curiosity, or the will to learn, information is unlikely to be acquired (Hunt, 1965). The primary concern of investigators related to motivation deal in factors which determine goal-directed behaviour. The intrinsic factors which arouse a curiosity to learn were explored by Harlow (1953) and Berlyne (1955) in animal studies with implications for human educational practice. From such studies, the affect of gratification was defined as motive. In recognition of the fact that students learn when they want to know something, educational
structures have been developed which trust the students to find out what is appropriate for them. This view led to the establishment of classrooms of open learning, such as in the Summerhill model established by Neill (1960). In such a system, the goals for learning are made known, which are strategically arranged in an enriched environment for self-paced absorption by highly motivated students released from direct competition with their peers.

However, despite the advantages of the heuristic model of self-paced open learning espoused by Neil (1960), and the principles of self-actualised learning subscribed to by Rogers (1961; 1969), it is inevitable that measurements of achievement must be applied in competitive situations for the purposes of certification, professional qualification, research, or to engender individual life-long growth patterns of learning (Atkinson, 1968; Lee, 1994; Suppes, 1966).

A cognitive theory of learning may be perceived as a process of reconstruction of individual perceptions (Tyler, 1965). Cognitive learning may be best served by consideration of the connectionism espoused by behaviourists with the Gestalt approach to learning made by Kidd (1959), Perls (1969), Perls, Hefferline & Goodman (1951) and Ryan (1966a). From these studies, Perls developed a form of transactional analysis, which subscribed to view persons as a whole organism, rather than a collection of fragmented parts. Whereas behaviourist psychologists appear to emphasise learning by tracing connections made by the individual and separate parts of a subject, those who favour the Gestalt approach, are concerned with the shape and form of the whole material at the outset (Kidd, 1959).
2.4 Preparation of the human psyche for CBL

According to Kidd (1959), Kohler (1925) exemplified the principles of Gestalt education by his use of chimpanzees to evaluate a system of learning which linked *insight* with *problem-solving* behaviour. Although Kohler's efforts may be seen as a forthright attack on the established behavioural theories of Thorndike (Kidd, 1959), when viewed in combination, the behaviourist theories of Thorndike, the teaching machines of Skinner, and the Gestalt learning of Kohler and Perls (1969), may be perceived as the forerunners of computer-based learning.

The main advantages of programmed learning are to be found in the active involvement of the learner in the process, enhanced by instant reinforcement and feedback. This process may be accelerated by an ability to regulate a self-paced delivery of information, providing opportunities for low achievers to compete with high achievers (Goldscmid & Goldschmid, 1974). Boredom and faulty equipment are the main reasons given for failing interest in mechanistic and programmed styles of learning (Cohen, 1984), which, nevertheless, have been reintroduced by the advent of innovative computer technology which allow for higher orders of thinking and learning (Hedberg, 1993; Jonassen & Wang, 1993; Lee, 1994; Reeves, 1992b).

2.5 Modern styles of learning and thinking

In a functional sense, apart from the mere joy of reading and viewing for the pleasure of it, the main purpose of learning is to stock the mind with information for later retrieval when required (Bayles, 1966). By the 1960s, learning was no longer considered to be a passive process for the absorption of knowledge by book reading or being lectured;
instead it was perceived to require active intervention on the part of the learner to reinforce its process (Goldscmid & Goldschmid, 1974; Ryan, 1966b).

For the next three decades, emphasis was placed upon activity programs, learning by doing, learning by contact with objects, preferably by self-directed activity in a life situation, as advocated by Clark and Romiszowski in 1992. However, despite this modernistic view, there was a surprising attempt to reintroduce the programmed style of learning initiated by Thorndike (1911 & 1932) in the guise of mastery learning from the time of Washburne (1922). According to Bloom (1968), mastery learning offers a powerful stimulus to learning for all students, rather than a high rate of achievement by the top 25%. The essence of mastery learning is developed by a reduction of complex behaviour patterns down to a chain of component parts. Hence, by mastery of each link in a chain of knowledge, any student can master even the most complex skills (Block, 1970 & 1971; Miller 1956). Block gave two well known examples of mastery learning, namely the Individually Prescribed Instruction (IPI) project at Pittsburgh (Glaser, 1968) and Stanford's CAI project (Atkinson, 1968; Suppes, 1966).

In the Stanford project, Atkinson described the use of CAI tailored to deal with individual differences in reading by tutorial programs in psycho-linguistics for first year university students. Each lesson contained main-line problems which the student was required to master by self-paced learning before going on to the next section. Computer monitors were programmed to assess student responses, and provide new problems, or remedial work, accordingly. Atkinson's results
indicate a great variability of learning rates in a seven month period, with a median index of 2,500 problems delivered to each student. These results were comparable to Glaser's work, in which the slowest student completed about 1,000 problems, whilst the fastest completed 5,000, showing a ratio of 1:5. Further, the number of problems completed on an hourly basis by the fastest students increased steadily over the seven month period, whilst it remained constant for the slowest students due to the digestion of remedial material. Nevertheless, when the experimental CAI group was compared to a control group at the end of the academic year, the CAI group performed better on average than their control group counterpart. It was of further interest to note from Atkinson's conclusions, that although it is commonly observed that females acquire reading skills at a faster rate than males, under CAI conditions of mastery learning, no statistically significant differences were given to rate the progress made by either gender.

It is noteworthy that the cumulative effects of innovation found in modern styles of learning may be measured by objective, or subjective data (Kimble & Garmezy, 1968), varied by the expectant trust exemplified by a doctor-patient relationship. Because the doctor is cast in the role of a healer by the patient in this expectant trust situation, it has become known as a placebo effect (Glick & Margolis, 1962; Rosenthal, 1966; Rosenthal & Lawson, 1964).

The power of a placebo effect can also be identified in other areas of experimentation. One of the most noteworthy is provided by the classical study conducted by Roethlisberger and Dickson (1939) at the Hawthorne plant of the Western Electric Company. One part of this study was directed at the manipulation of systems of payment and
working conditions related to their effects upon the end-product of an assembly line. In essence, throughout the experiment, the rate of production continued to increase despite specific injunctions to its female workers not to be competitive, or to make a race out of the experiment. Subsequently the workers reported that they were not conscious of working particularly hard throughout because they enjoyed the social setting. From these results it became clear that the participants were less influenced by financial reward, but more motivated by the innovation and attention created from the experimental situation. Hence, this important outcome of Roethlisberger and Dickson's study was to become known as the *Hawthorne effect*.

Rogers (1961 & 1969) raised questions about individualised learning at secondary and higher educational levels in an effort to invoke change. Rogers identified the need for personal involvement in an atmosphere focused upon learning rather than teaching, where the educator creates an environment to facilitate the discovery of information. In this way, Rogers may be said to have initiated the modern process of autonomous discovery-learning.

In response to the efforts of Rogers and the behaviourist methods of Thorndike and Skinner, other influences of change have taken place in the design and development of methods to deliver knowledge to learners. These include the work of Bennis, Benne, and Chin (1961), who advocate a need to change interpersonal relationships and group action during the educational process combined with the power of self-actualisation advocated by Coombs (1962).
Knowles (1970) viewed education as an evolutorial process from childhood to adult life. Knowles describes a pedagogical evolution of subject centred transactions in childhood, to a concept of andragogy, which is the art and science of helping adults to learn. Hogan (1994) identified a need to empower learning by stages of transition from a logical commencement to a satisfactory resolution. Furthermore, such information may be presented in short or long bursts, with interventions lasting from minutes to months. Hogan suggests that humans are more likely to remember the beginnings and endings of learning sessions, rather than content in the middle, therefore there is a need to address the elements of each part. Hopson and Scalley (1981) defined empowered learning as a process which selectively identifies options and alternatives, some of which may be discarded when seeking knowledge. At an emotional level, these transitions can be related to the affective domain of learning (Boud, 1985; Batts & Wilkes, 1993; Heron, 1992). Heron perceives an upward hierarchy of four basic psychological modes of learning, namely; affective, which entails feelings and emotions; imaginative, which relates intuitive imagery to perceptual memory; conceptual, which is reflective, discriminatory; and practical, which converts intentions into actions.

2.6 From Pedagogy to Andragogy

Significant stages of change in the human processes of learning often overlook discrete differences between childhood and adult life. These differences may be observed as an egocentricity in childhood leading to self-actualisation in the adult (Knowles, 1970; Smith, 1991). The work of Piaget from 1924 to 1937 exemplifies interactive pedagogy as an engagement between the student and teacher (Joyce & Weil, 1972). Piaget established progressive steps in the development of individuals,
founded upon the egocentric principles of childhood which prepare the individual for an external view in adult life (Bond, 1992). Regrettably, although Piaget's work spanned six decades with a massive line of research into the intellectual development of children, his theories have not been fully accepted because they failed to apply sufficient empirical data for curriculum development (Flavell, 1963; Joyce & Weil, 1972; Sigel, 1969; Sullivan, 1967).

Specific research on how human beings learn and remember is of the essence, with a shift from Thorndike's connectionism to information processing (Bond, 1992; Gagne, 1977; Joyce & Weil, 1972) and cognitive strategies (Thompson, 1989). These concepts are extended by Knowles (1970; 1980; 1984) and Smith (1991), who advocate a developmental model of change from pedagogy to andragogy. These principles lead to a self-concept of inquiry learning supported by Brandes and Ginnis (1986) and Bond (1988) who promote an interactive process of achievement to reach the autonomous student-centred learning outlined by Maslow (1954) and Rogers (1961; 1969).

To avoid the risks of superficial learning associated with a linear curriculum, Romiszowski (1992) advocated the use of Keller's (1983) ARCS educational model, an acronym for Attention, Relevance, Confidence and Success. It is Keller's axiom to use these four components to engage the emotional state of the learner in a particular domain.

Nevertheless, although most researchers support the notion of user control in a self-directed learning environment by computer, warnings also pervade about the dangers of unlimited freedom whilst learning.
Marchionni (1988) advised that an excess of freedom to learn may lead to confusion because it places too much responsibility upon naive learners. This naivety can be correlated with a level of investment to previous knowledge, hence a lesser level of prior achievement exhibited by a student is likely to lead to a reduction in the effectiveness of subsequent learner-control (Balajthy, 1988; Ross, Morrison & O'Dell, 1988). Not only may low ability students perform poorly when allowed freedom to learn (Balajthy, 1988), they may opt to skip important concepts, or quit from the process too soon (Chen, 1989). Furthermore, Chen suggests that self-directed learning may only be effective for high-ability students, or for those with a satisfactory level of previous experience in its content.

However, despite these concerns, the contemporary focus of education is upon learning (Reeves, 1992) based upon a precept that the primary construction of knowledge is an on-going cumulative process where knowledge begets more knowledge (Gagne & Glaser, 1987; Glaser, 1984). Reigeluth and Stein (1983) contend that the process of learning involves the assimilation of new information within an hierarchical schemata, namely by cues which facilitate the transfer of short-term into a long-term memory pattern. In an ideal learning situation, content is encoded by cues for delivery in chunks, as outlined by Miller (1956). In this way, by use of a well defined framework, new information can be subsumed into a long-term mode ready for later retrieval (Ausubel, 1968). Furthermore, when sufficiently motivated, higher orders of thinking and information processing can be actively transferred from short to long term memory, as in either the episodic, or semantic mode espoused by Tulving (1979). Once stored by an appropriate neuro-
physiological process, long term information is ready for retrieval by facilitation (Gagne, 1985).

To meet the needs of a fast-paced environment, it is becoming increasingly important to develop life-long learners at the point of entry to the next century (Reynolds & Ehrlich, 1992). Although some lecturers may be effective motivators, educational research has shown that lectures cannot be considered efficient in the stimulation of student learning (Laws, 1991; Hestenes, Wells, & Swackhamer, 1992; Lee, 1994; Lee & Kemp, 1994; Redish, Wilson, & McDaniel, 1992). Learning may be re-defined as a highly interactive process in which the lecturer and learner become engaged in a learning 'conversation' (Pea & Gomez, 1992).

Learning may also be considered as the social development of shared cognition (Brown, Collins, & Duguid, 1989) in contrast to knowledge, which is no longer regarded as the mere representation of stored experience, but a novel re-construction of information which continues to develop in relation to practice in the community (Clancey, 1992; Rochelle & Clancey, 1991). Boot and Hodgson (1987) make a clear distinction between two models of learning, a traditional model characterised by the dissemination of learning, and a developmental model. Rowntree (1992) elucidated the differences between these two approaches. The dissemination model was defined as the acquisition of facts, procedures and knowledge passed from the teacher to learner, whereas the development model involved a co-dominance between teachers and learners focused upon the empowerment of the individual.
The adoption of a developmental model links an acceptance of other major educational themes, such as 'action learning', 'the learning organisation' and a 'competency approach' (Mumford, 1993). According to Eldred (1994) the central issue of open learning is that these objectives should be developed for the individual within a framework of independence and autonomy. In an environment where young people are encouraged to learn how to think, develop concepts, raise questions and solve problems, computer enhanced learning (CEL) is of the essence to help promote such skills (Toomey, Mahon & Thalhoti, 1994). With the implementation of computerized styles of learning, it not only becomes important to determine effective instruments to test the quality and retention of knowledge by the learner, but also to quantitatively evaluate its method of delivery (Lee, 1994). In a research project which explored these problems in mathematics, Ring (1994) demonstrated the effective use of computer assisted testing (CAT) to meet these objectives. Whilst most CAL regimes rely upon multiple-choice question techniques, the results of Ring's pilot study have broadened the scope of standardised testing to allow a wider variety of interactive questions, which not only provide quantitative data for testing, but also gain qualitative information from learner feedback.

2.7 Examinations, competency, measurement, and marking
Although a controversial issue, examinations and marking are of particular importance in the field of educational research, especially to determine levels of individual, or group achievement (Pilliner, 1968). In defence of examinations and marking, to the educator they provide feedback and measurements to validate the effectiveness of teaching and other procedures, to the student they provide a stimulus and a goal.
Furthermore, tests and examinations are a form of selection for entry to intellectual pursuit, or later, as proof of public confidence in the end product to guarantee professional competence (Entwistle & Nisbet, 1972; Lee, 1994; Oppenheim, Jahoda, & James, 1967).

Professional education is an expensive exercise. To make the best possible use of its facilities and corporate talent, it is important to evaluate its progress and relative achievement (Ebel, 1965). Nevertheless, conflicts of value inevitably arise between the needs of individuals and those of institutions. Both may work towards a common goal, but use different criteria for administration, promotion, and advancement. It is obvious that the need for measurement required by an institution for selection at the point of entry, followed by validated progression, to be awarded by a label of professional competence at the end of it (Entwistle & Nisbet, 1972; Oppenheim et al., 1967; Shepard & Jensen, 1990), requires a logical distribution of marks to rank levels of achievement and ability throughout. To the contrary, if the personal growth and development of each individual is of prime importance, as in the autonomy and self-actualisation processes subscribed to by Clark (1983; 1985; 1986; 1989), Griffith, (1987), Higgs & Boud (1991), Lee (1994), Perls (1969), Reeves (1992a, 1992b & 1995), and Rogers (1961; 1969) then all grades of achievement must be confined to evaluate and motivate the learner. From these observations, there is a clear need to reach a compromise of purpose to meet the requirements of institutions, professions, public confidence, and quality of satisfaction for individual participants. Therefore, to meet institutional and personal requirements of assessment, it is essential that criteria of objectivity are built into each system of measurement (Hamburg, 1977).
To address these problems at an institutional and professional level, a progressive form of review of competencies is underway in Australia. The objectives of competency-based education, are to gauge attributes and goals to meet vocational and professional standards, and to set levels of comprehension and understanding to meet acceptable criteria of evaluation, appraisal and performance (Nicholls, 1992). In essence, once key competencies have been determined, progression and transfer may become more feasible between secondary schools, tertiary institutions, and professional bodies. In this way, barriers of transfer from one career path to another may be overcome; child-care workers can aspire to become teachers; members of the metal trade may become engineers; and health workers become doctors (Nicholls, 1992).

However, irrespective of whichever public value systems are in operation, it remains necessary to obtain objective data for analysis from them to draw conclusions about their respective processes, and the quality and progression of subjects within them (Hicks, 1988; Kerlinger, 1973; Leedy, 1993; Lee, 1994; Runyon & Haber, 1973).

Two major forms of written tests are available to evaluate academic achievement, namely by answering essay questions, or by responding to objective tests. The former requires a student to formulate a planned answer expressed in writing. The latter requires a student to select an answer from several designated alternatives. The main advantage to the first option, is that its style of presentation is uniquely individual and that it requires the candidate to reassess previously learned material for presentation in a cogent form to meet the requirements of the examiners. The main disadvantage to the first option, is that the time spent on its marking is labour intensive and open to subjective
interpretation by the examiner (Ebel, 1965; Hicks, 1988; Lee, 1994; Leedy, 1993; Runyon & Haber, 1973).

It is undeniable that the task of creating an original answer to meet the requirements of a well prepared and challenging essay question is a valuable exercise. Such an answer, not only requires an accurate recall of relevant principles and factual detail, but also demands an ability of coherent expression and logical presentation. This style of questioning is well suited to problem-solving situations, on a small group basis (Anbar, 1987; Andrews, Schwarz, and Helme 1992; Barker & Yeates, 1988; Barrows, 1983; 1986; & 1988; Barrows & Tamblyn, 1980; Lambert, 1992; Lee, 1994; Reeves, 1992a & 1992b; Warner, 1989). However, there remains the problem of labour intensity (Glaister, 1994; Lee, 1994) when marking and grading large groups, with an increased risk of subjectivity in a time-pressure squeeze at the end of a defined academic period.

According to Ebel (1965), there is a converse correlation of activities between essay and objective tests. Namely, for the candidate, most of the time is devoted to thinking and writing in an essay test, whereas in an objective test, most of the time is spent in reading and thinking. Furthermore, the quality of an essay test is largely determined by the skill of the examiner, whereas, the quality of an objective test is largely determined by its construction. From this, it becomes clear that the essential differences between essay and objective tests lie in the reliability of their evaluation and the quality of their creation (Clark, 1983; 1985; 1986; 1989; Ebel, 1965; Entwistle & Nesbet, 1972; Lee, 1994; Pilliner, 1968; Shepard & Jensen, 1990).
When faced with the problems of over-crowding and time-pressures, compounded by a need for measurement, then objective tests become realistic and inevitable (Ebel, 1965; Kieslar, 1953; Lee, 1994; Leedy, 1993). Objective test items may consist of true-false, multiple-choice, or a combination of both. Reputable multiple-choice questions may be prepared to generate one correct solution, enveloped by four closely identified distracters. Furthermore, multiple-choice questions may be compounded by several selections of variation in the construction of the primary question. Any ambiguity in the form of the questions is readily dealt with by a process of developmental evolution. In this way, series of objective questions can be generated, validated, and modified by quality assurance gained from previous candidates (Lee, 1994; Lee & Kemp, 1994).

As a result of previous research data, for the purposes of this research project, it is considered preferable to mark and grade objective tests as follows. To prevent guessing in true-false tests; +1 is awarded for a correct response, -1 for an incorrect response, and zero for no attempt (Bindman & Elleway, 1985; Lee, 1994; Lee & Kemp, 1994). Multiple-choice questions were carefully created to allow for one or several correct responses, according to the level of complexity and problem-solving content engendered by each question (Bindman & Elleway, 1985; Harkin, Dixon, Reid, & Bird, 1986; Lee, 1994; Lee & Kemp, 1994; Pollard & Davenport, 1994; Stewart, 1990).

Whatever the examination style, the importance and rapidity of feedback is essential. Student benefit gained by the release of recorded results is immense (Bindman & Elleway, 1985; Gledow, Ladiges, Dodds, Handasyde, Lawrence, & Burgman, 1993; Woolfolk &
McCune-Nicolich, 1984). It is obvious that there is a decay in the power of reinforcement and interest compounded by any delay between the time of the examination and the realisation of its results. This problem can be readily overcome by the application of interactive computerized testing and feedback to provide instant reinforcement (Lee, 1994; Lee & Kemp, 1994).

2.8 Exponential growth
According to Dean (1989), the application of computer technology in higher education may be attributed to the development of the first digital computer by Antanasoff at Iowa State University in 1939, when teaching programming and computer science to engineering students. Later, Bush (1945) and Nelson (1967) conceptualised the storage, retrieval and networking of textual information via computerized hardware. The generic term 'Hypertext' was first used in the early 1960's by Nelson (1967, 1988) to describe the concept of non-sequential writing. A Hypertext system is one in which the information is linked to enable users to create unlimited, individual, pathways throughout a body of knowledge. In the same way, we owe it to Nelson (1989) for the term 'Hypermedia' as an extension of Hypertext to include other media, such as graphics, video, and animation. Further, at a comprehensive level, the definitive notions of Hypertext and Hypermedia have been re-categorised by the term 'Multimedia' to represent a convergence of information, such as text, data, graphics, video, and audio into a common digital platform (Bates, 1994) which may be transmitted on the much publicised Information Superhighway (Booth, 1994). Hence, the linkage of these concepts has become the basis of computerized techniques to empower autonomous learning
(Bates, 1994; Booth, 1994; Clark, 1992; Lee, 1994; Reeves, 1992a; Ring, 1994; Romiszowski, 1992).

The development of computerized learning techniques originate from the time of Bush (1945) and Nelson (1967; 1988), to show that a growth pattern of computerized hardware and software has already been in operation for more than two decades to supplement traditional methods of teaching and learning (Levien & Mosmann, 1972; Romiszowski, 1992). Furthermore, Gates from the Microsoft Campus in Seattle, interviewed by Appleyard (1994), declared computers to be the most potent and explosive technology on earth. Gates asserts that the development of computers and companion software has barely begun, with a power that is growing exponentially, to double itself every 18 months, and will continue to do so for the next 20 to 30 years (Appleyard, 1994).

2.9 Meta-analysis and reactions to it
Realistically, Kemeny (1984) suggested five good reasons for the application of computer technology to higher education, namely; to understand the civilisation we live in; to be in touch with the main source of acquiring human knowledge; to improve our minds; to get a job; because it is fun. Nevertheless, CBL educational software is often a glitzy version of old technology, which can be overcome by problem solving in a case-based learn-by-doing environment (Fieffer & Allender, 1994). These authors describe the enhancement of learning about events in the real world by 'doing' in a computerized simulated environment. In a discussion of the complexities of educating teachers how to integrate educational software into the curriculum, Thompson
(1989) emphasised the cognitive orientation of computer learning environments.

When reviewing the problems of educational research and review, Glass, McGaw, and Smith (1981) declared that the importance of a scientific work may be measured by the number of publications it renders superfluous to read. In a more serious mode, these authors also explored the value of meta-analysis in social research by objective, quantitative and statistical procedures. Although used previously, meta-analysis was defined by Glass (1976) to mean 'analysis of analysis' from which conclusions may be drawn from a comparative overview of findings from several studies based on the same theme.

In the introduction to an investigation of computer-based education (CBE), Kulik and Kulik (1986) summarised its evolution from the teaching machines of Skinner (1948, 1956, & 1968), who encoded programmed styles of instruction, to its use in a university classroom for individualised learning. In an elucidation of 17 study characteristics from 101 controlled evaluations of computerized learning in higher education, Kulik and Kulik (1986) extended the findings of primary research projects and narrative reviews by meta-analysis, using the quantitative techniques espoused by Glass, McGaw, & Smith, (1981) and Kulik, Bangert and Williams (1983). These authors typify the objective use of meta-analytic procedures to locate suitable computerized studies to apply quantitative techniques to describe and explore the relationship of study features with their outcomes.

In addition, Glass et al., (1981), determined a technique to identify effect-size (ES) from which to compare the effectiveness of a treatment
group to the control group in standard deviation (SD) units. Furthermore, Kulik and Kulik (1986) were of the opinion that because computers had changed dramatically after 1978, becoming smaller, more reliable, faster in operation and less expensive since then, that the results of previous studies were no longer appropriate. From this standpoint, Kulik and Kulik questioned the validity of previous research in CBE and undertook a meta-analytic approach to compare 101 studies by the method outlined by Glass, et al., (1981), finding no substantiated differences in effectiveness between CBE, computer-assisted instruction (CAI), computer-mediated instruction (CMI) and computer-enriched instruction (CEI) programs at the university level, showing that students at this level can adapt to a variety of methods used in computerized teaching. However, the meta-analysis of the 101 studies undertaken by Kulik and Kulik (1986) show qualitative differences in recent pre-university findings, namely; in elementary schools, where CAI programs of drill, practice and tutorial instruction produce favourable results, whereas CMI methods demonstrated weaker findings (Kulik, Kulik, & Bangert-Drowns, 1984). However, in high schools, CAI and CMI produced positive results, with minimal achievement in CEI programs (Bangert-Drowns, Kulik, & Kulik, 1985). In the same way, McNeil and Nelson (1991) used meta-analysis to study the cognitive affect of interactive video (IV) instruction over a ten year period. Sixty-three studies met stringent selection criteria out of 367 studies to investigate IV, obtaining an achievement effect of 0.530, to conclude that guided and programmed IV is preferable to learner-controlled IV as an effective form of instruction, a result which was equated to be similar to that of computer-assisted instruction.
According to McKenna (1993), who culled 442 studies from on-line computer searches, from which 26 met strict selection criteria, one advantage of meta-analysis is that its results not only provide quantitative information about the overall effectiveness of educational innovation, but also allows inference to be drawn by comparison of more obscure factors of greater, or lesser magnitude. In this way, it is possible to draw conclusions from multiple studies which may not be identified by analysis of one alone. McKenna hypothesised that meta-analysis of computer-based items would provide information for the development of more innovative macroeconomic simulations. He used the principles of method attributed to Glass (1976) to obtain findings which may be applied to any other subject. The value of McKenna's efforts are to be found in its analysis of variance, using independent variables for cross-comparison of factors which influenced the outcome of the 26 studies. The schemata reviewed studied characteristics linked to a summary of meta-analysis results. The results were related to the subjects taught, gaming and non-gaming simulations, graduations of complexity, use of on-screen hints, graphics, student characteristics, gender, teaching strategies graded to relate single or multiple use, teacher-instructor involvement, group sizes, test and control methodologies, and involvement of the evaluator. From McKenna's results it is clear that the incorporation of graphics is likely to increase the effectiveness of learning, with locally developed courseware found to be more effective than commercial packages. Further, that computer simulations applied at the university level are more effective than those in either primary or secondary schools. The mean effect-size of 0.66 for simulations at the tertiary level moves the average student from approximately the 50th to the 75th percentile. Computer simulations appear to be most effective in adult education, with an average effect-
size of 1.13 (Kulik, Kulik & Schwalb, 1985), an average effect-size of 0.36 at the university level (Kulik, & Kulik, 1985), and 0.49 at the secondary school level (Kulik, Bangert, & Williams, 1983). Although not statistically significant, McKenna was able to determine a greater average effect-size in low and high ability students than in those of average ability.

Although meta-analysis techniques have been applied to compare computer-assisted learning with traditional methods of instruction (Bangert-Drowns, Kulik, & Kulik, 1985; Clark, 1986; Kulik, & Kulik, 1986; Kulik, Kulik, & Cohen, 1980; McNeil & Nelson, 1991) reservations remain about learning by computer (Richards, 1989). According to Clark (1983), when referring to the absolutes and effects of educational delivery media, declared computers to be: 'mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition'

These reservations were mainly expressed about the educational value of hypermedia and multimedia, exemplified by other keynote speakers at an international symposium on multimedia held in Perth, 1992. Three of the main keynote speakers, including Clark, who declared that the mere availability of interactive multimedia (IMM) does not guarantee learning (Clark, 1992, Reeves, 1992a; Romiszowski, 1992). Clark also declared 'books to be better', countered by Looms, who quoted Karpatschof (1991) to define the use of interactive computers as: 'the ability to solve tasks which could neither be solved by computers without people nor by people without computers'.

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Furthermore, in an atmosphere which questions the value of interactive multimedia, declaring that its presence does not automatically guarantee learning, Reeves (1992a & 1995) recommends new directions of research to guide future development. In a keynote address at the same symposium, Reeves cited the views of Bransford, Sherwood, Hasselbring, Kinzer, and Williams (1990), who advocate a situational notion of 'anchored instruction' to develop the construction of knowledge by 'using it' when discussing problems associated with regurgitation of memorised information. These observations are supported by Anbar (1991), who defined knowledge as an effective problem-solving ability through mastery of information learned. To avoid the risk of mere regurgitation when testing, Anbar gave evidence in support of computer driven, interactive multiple choice questions randomly interspersed with situational and orally emulated questions with a natural language input. From this, it becomes clear that to be effective, knowledge gained by learning from interactive multimedia, must be action orientated, useful, and cost-efficient.

Reeves (1992b) is of the view that the absorption of information must contain a dynamic affect, otherwise its retention becomes inactive, or merely 'inert' knowledge. However, inert knowledge may be resuscitated by the appropriate test methods espoused by Anbar. In a separate paper which focused upon interactive learning systems, Reeves (1992b) identified important pedagogical dimensions of interactive learning. These dimensions include epistemology, pedagogical philosophy and theory, goal identification, instructional sequencing, the role of errors and the teacher, learner control, and cooperative learning. Reeves (1992b) enhanced each of these concepts into right and left sided values. Those listed on the left of the concept are objective
whilst those on the right are constructive. For example, to the left of epistemology is objectivism and to its right is constructivism; the left of goal orientation is sharply-focused, to the right it is unfocused; to the left of the role of instructor is teacher proof, to the right is equalitarian facilitator; non-existent is placed to the left of learner control, with unrestrictive to its right; and unsupported to the left of cooperative learning, with integral to the right of it. From this it is clear that Reeves favours the contractivist outcomes to the right of the listed pedagogical framework. Vagaries of such restriction have been challenged by Henderson (1994), who argues a need for pluralism to meet differing cultural requirements. For example, Aboriginal and Torres Strait Islander students are experiential rather than error free learners. In essence, Reeves appears to support errorless learning, whilst Henderson recommends facilitative learning by trial and error. The recognition of the wide range of pedagogical dimensions shown by Reeves possesses significant merit, as does the issue that both sides of the paradigm are not mutually exclusive and can be incorporated to meet the cultural differences shown by Henderson.

Reeves (1992a) described the complaints of medical educators about highly selected medical students who can absorb myriads of facts, concepts and rules within the first two years of medical school. Regrettably, these same students are frequently unable to implement these facts during the clinical phase of their education. Reeves observations coincide with those of Barrows, 1983 and 1986; Anbar, 1987; Barker & Yeates, 1988; Warner, 1989; Andrews, Schwarz, and Helme 1992; Lambert, 1992; and Reeves, 1992a; all of whom espouse the need to redress this situation by a problem-based medical curriculum which incorporates case-studies and interactive learning.
Thompson and Williams (1985) summarised problem-based learning as, the encouragement of learning and acquisition of knowledge to make it easily remembered for retrieval in a professional setting. Furthermore, these authors subscribed to processes for the enhancement of analytical skills to evaluate and determine solutions. According to Thompson and Williams, these processes ensure the development of patterns of learning, independent of teaching, which will be sustained by the student throughout professional life. Therefore, the quality of processes implemented during the formative stages of problem-based learning is imperative (Newble & Cannon, 1991). According to Newble and Cannon, unless attempts are made to introduce a deep approach to problem-based learning, students are likely to merely acquire information at a superficial level, which can be 'dumped' shortly after assessment. These authors define superficial learning as a situation motivated by a fear of failure, fulfilled by rote learning to memorise facts for later regurgitation at times of assessment. To avoid this consequence, these authors recommend a deep approach to learning, whereby students are motivated to absorb content by the arousal of a vocational interest in the subject. These outlined principles are in support of those advocated by Barrows, (1983, 1986, & 1988); Barrows and Tamblyn, (1980); Birch, (1986); Boud and Felletti, (1991); Lambert, (1992); Stevens, (1989); Reeves, (1992a); Khoo and Kingsland, (1994); and Lee, (1994).

To counter arguments made regarding hypermedia systems not being entirely satisfactory to comprehend large sets of information (Halasz, 1991; Hutchings, Hall, & Colbourn, 1992; Malcolm, Poltrock, & Schuler, 1991), more discrete techniques of differentiation for its presentation have been made to address the issue. In the main, this has
resulted in the formation of closed and open systems. In essence, examples of closed systems include applications that are specific to an individual, such as electronic mail, spread sheets, or word processor items. Closed systems of operation may be contrasted with open systems, which enable its users to navigate through layers of abstract information linked to local or international networks (Fountain, Hall, Heath, & Davis, 1991; Davis, Hall, Hutchings, Rush, & Wilkins, 1992; Hall, Heath, Hill, Davis, & Wilkins, 1992; Hill, & Hall, 1992).

An example of the open system of reconfiguration can be observed in the Microcosm model (Fountain, et al., 1991; Heath, 1992; Hill, Wilkins, & Hall, 1992) adapted for the HiDes (Historical Document Expert System) filter to analyse answers generated by CAL students whilst browsing and investigating historical information through a hypermedia network of background material (Colson & Hall, 1991). Other examples of an open system of information management at a global level would include Internet (Appleyard, 1994) and WestLink, an experimental delivery system of learning from the Western Australian Learning Network for distance education students at remote sites (Rehn, 1993) together with those at a more parochial level, such as Recreation Perth, a database for occupational therapists (Cameron, 1993), SOCCER, a computer managed environment developed to empower self-directed learning in anatomy by physiotherapy students (Lee & Allison, 1993; Lee, 1994), and a computer-based multimedia system applied to physics (Loss, Zadnick, Sands, & Treagust, 1993).

In addition, concerns raised about the use of hypermedia and multimedia for educational purposes are being addressed by elucidation of the need for research into higher orders of learning and thinking
(Hedberg, 1993; Jonassen & Wang, 1993; Reeves, 1992b) together with an optimum balance of interactivity at computer work stations. Bork (1987) suggests an ideal time of student responses at a computer work station should be no less than 15 to 20 seconds. Thus, learners are now being encouraged to think rather than react (Ellis, 1994).

Mitrani and Swan (1990) assert that computerized learning differs from the more traditional education media because it is interactive, and provides a malleable model for the presentation of abstract ideas. These authors also outline methods which enhance the cognitive process when constructing programs. Reeves (1992a), defines learning as a process of knowledge construction, knowledge dependent and highly tuned to the situation in which it takes place. From this aspect, he advocates the benefits of problem-based approaches to computerized learning and suggests it should be highly visual to involve the student at a cognitive level, with operative, rather than figurative knowledge (Arons, 1984; Meals and Kabo, 1980; Rochford, 1985).

Computer-assisted learning has been in use to educate health professionals since Bitzer pioneered computer-assisted instruction in nursing courses through PLATO, an acronym for Programmed Logic for Automatic Teaching Operations in 1963 and 1966, followed by other computerized modalities applied to nursing (Bitzer & Bitzer, 1973; Belfry & Winne, 1988; Hebda, 1988; Paulanka, 1986).

As the S-R programmed learning styles of the behaviourists (Skinner, 1948, 1968; Thorndike, 1911 & 1968) were supplemented by more cognitive strategies, there is a prevalent view that technology has advanced to a level where it is preferable to present interactive
multimedia in ways which are more consistent with how humans think and learn (Jonassen, 1991; Voon, 1992). Hence, from a cognitive standpoint, the learner can be motivated to assume an active role which implies an equal ability and opportunity for learning (DeVesta, 1987). The comments of DeVesta and Jonassen are enhanced by those of Kinzie (1990), who supports provision of learner control by enabling students to tailor their instructional experiences to coincide with personal needs and interests.

In terms of hypertext and hypermedia (Nelson, 1967, 1987, 1989), among the most prominent examples of international sophisticated educational research, using hypertext systems, are the Intermedia Project at Brown University (Yankelovich, Haan, Meyrowitz, & Drucker, 1988), the ILAB Project at the University of Southampton (Hall, Hutchings, & Carr, 1992), the StrathTutor Project at the University of Strathclyde (Mayes, Kibby, & Watson, 1988), and the Perseus Project at Harvard (Crane, 1987). However, with the advent of interactive multimedia Alexander and Frampton (1994) identified a contemporary mixture of 'active proselytisation, utopian futurism, creative experimentalism and the implementation of novel systems'. From this, there is a clear need for a review and re-establishment of learning practice and its integration into research-based modern computer driven educational theories. In this way, there would be an involvement of cognitive skills with higher orders of thinking for integration with CAL programs (Hedberg, 1993; Jonassen & Wang, 1993; Voon, 1992). However, whatever the meaning of higher orders of cognitive skill and thinking and metacognition, more of it is likely to take place in institutions of higher learning (Alexander & Frampton, 1994).
CAL is represented in dental education by the Flexible Dental Curriculum at the University of Kentucky (Mast & Watson 1976) and a comparison of CAL with tutorial teaching in dentistry at the University of Manchester (Levine, Jones, & Morgan, 1987). These efforts have been advanced by an evaluation of a computer-based project and follow-up questionnaire to sixty-five dental practitioners throughout the United Kingdom by Pollard and Davenport (1994).

Evidence of the established use of computerized learning in medical schools has been shown by Holley and Heller (1984), who compared the use of microcomputers with tutorials to teach anaesthesiology and Harkin, Dixon, Reid and Bird (1986), who used computers for an interactive presentation of pathology by microfiche and slide transparencies. In a survey of CAL used in British medical schools, Florey (1988) recommended inter-medical school collaboration for the development and use of resources to rationalise costs, whilst Wigton, Poses, Collins, and Cebul (1990), reported the effective use of CAI to improve the diagnostic skills of experienced student-health physicians. Despite this evidence, Lambert (1992) cited difficulties experienced by trainee specialists, or Registrars, in apprenticeship situations with a Consultant supervisor. As in all apprenticeship situations, the supervisor-trainee relationship is one dominated by strict conformity to a role model of medical education. Although Lambert perceived the value of CBL at the undergraduate level of medical education, a corresponding distrust of 'machinery' in postgraduate medical education was revealed as a Luddite Mentality Factor, or barrier to computerized learning.
2.10 Information explosion

Mitrani and Swan (1990) assert that CAL differs from traditional education media because it supports dynamic media which is sufficiently malleable for the presentation of abstract ideas. Furthermore, Mitrani & Swan demonstrated research in support of problem-based learning and problem-solving by over 300 students ranging from elementary school to graduate school, concluding that CAL is more effective than traditional methods. Reeves (1992a) and Henderson (1994) reinforced these findings to define learning as the processing of thinking and knowledge tuned to the situation in which it takes place, advocating the benefits of a problem-based approach to computer-driven learning.

Traditional applications of medical art are used to present graphs, charts, clinical illustrations, 3-D models, videos, textbooks and journals. Currently, with the emergence of computer technology, creative artwork is being combined with scientific data to present medical and surgical information. In this environment, the growth of software to supplement traditional methods of teaching and learning which compare studies of the effectiveness of CAL with traditional methods (Appleyard, 1994; Cameron, 1993; Kulik, & Kulik, 1986; Kulik, Kulik, & Cohen, 1980; Lee, 1994; Lee & Allison, 1993; McNeil & Nelson, 1991), has resulted in an explosion of information. Furthermore, it is frequently stated that art and science are diametrically opposed disciplines (Mahoney, 1990), the former being creative and imaginative, the latter being based upon objective investigation and factual reporting. However, with the explosion and exponential growth of computer technologies (Appleyard, 1994), there is a concomitant danger associated with this surging expansion which
may outstrip the necessary quality of research for the validation of emerging multimedia.

2.11 Information overload

The corollary of this information explosion leads to an information overload (Lee, 1994). To accommodate this sustained explosion of knowledge, CBL has been incorporated into many areas of medical education (Hannan, 1991; McCracken & Spurgeon, 1991; Starkweather, 1986), with ample evidence to affirm its efficiency (Abik, 1994; Fincher, Abdulla & Sridharan, 1988; Lee, 1994; Lee & Allison, 1992 & 1993; Lee & Kemp, 1994; Prentice & Kenny, 1986; Teh, 1993). Nevertheless, a continual risk remains that these techniques may be used empirically without proper research into their development and correlation with the intellectual processes of learners (Lee & Allison, 1993; Lee & Cameron, 1994). The precise mechanisms by which information is acquired from CBL is still poorly understood, which, according to Kidd, Hutchings, Hall, & Cesnik (1992), is similar to the diagnostic procedures presently used by clinicians.

2.12 Intuitive links

Evidence of the effective use of CBL in medical schools is shown by Holley and Heller (1984), Harkin, Dixon, Reid, and Bird (1986), as well as Wigton, Poses, Collins, and Cebul (1990), who have successfully used CAI to enhance the diagnostic skills of experienced physicians. Because the education of modern healthcare professionals requires the assimilation of detailed information from an ever widening variety of contrasting sources (Lee, 1994; Shortliffe & Perreault, 1990), such information can only be absorbed by individuals at a conceptual level, causing medical educators to create ‘intuitive’ links

2.13 Computer anxiety and lifelong acquisition of knowledge

With greater exposure to CAL in kindergarten, primary and secondary schools, students are being well prepared for its content in integrated learning at the tertiary level without observable gender differences (Belfry & Winne, 1988; Heppell, 1994; Toomey, et al., 1994). However, despite the observations of Kirchoff and Holzemer (1979) that nursing students show positive attitudes to computer-assisted instruction, it is important to take heed of computer anxiety experienced by some first year university students, especially females, as identified by Clarkson & Pollock (1993). Current risks of gender based negative attitudes towards computer-related learning are also born out by Volet and Styles (1991), which may be ameliorated by a forth-coming publication which explores the implications of feminist theory, gender, and IMM instructional design (Henderson 1994). McKenna (1993) partly addressed this issue during meta-analysis of 26 out of 442 studies, when finding a coefficient of correlation between the effect-size and percentage of males to be -0.18, with a significance level of 0.11 (n=49). According to McKenna, although these data were not considered to be statistically significant, they suggest that a higher percentage of males in a study may be associated with a reduced effect-size.

Several studies have identified gender differences in attitudes and performance when using computers (Cameron, 1993; Hattie & Fitzgerald, 1987; Kirk, 1992; McKenna, 1993). In meta-analysis of research involving gender and computers at the secondary level, Hattie
and Fitzgerald could find no difference in achievement by gender, but
differences in attitude became more marked as students progressed
through the system. Although the number of students who enjoyed
computers was comparable throughout, a significant number of females
actively disliked computers. Upon further scrutiny, these authors
identified subjective reasons for this ardent dislike, namely; computers
being associated with machines and therefore masculine; computer
games being male dominated; females being more socially orientated
with a preference for human response; females seeing little use for
computers in their future lives; and a patriarchal pattern of computer
use in the home. These findings were supported by Cameron (1993)
who reported a tendency of computer anxiety by previous students in a
study which investigated the effectiveness of first year occupational
therapy students to access a computerized database. The age distribution
of the population (n=53) was shown to be 72% below 20 years of age,
13% between 20 and 25, 5% between 26 and 30, with the remaining
10% above 30 years of age. Although it may be assumed that recent
high school graduates are more likely to be computer literate, the
Cameron study could find no statistical difference of ability between
members of its population to access a computer database. Furthermore,
no discernible differences about computer interest and literacy could be
determined by gender. Of the 53 first year occupational therapy
students interviewed only 8% (n=4) were male, one of whom had
completed an upper school computing unit, whereas of the 92% female
students (n=49) only three reached the same level. Although these
results may represent a gender ratio of computer interest and literacy,
they merely indicate a trend which cannot be considered statistically
significant.
In the same vein, Khoo (1994) referred to the danger of overdoing the presentation of such materials with colour and gimmicky animation, so much so that learners are dazzled by the media rather than the message, which would appear to be adverse to the Hawthorne effect identified by Roethlisberger and Dickson in 1939. Koo referred to this phenomena as cyberphobia. Nevertheless, with the implications of lifelong computerized patient record keeping, questionnaires, interactive cardiac monitoring, together with the proposed interchange of clinical information and consultations between Australian doctors and others in the Asia-Pacific region via the Telemedicine Centre to be located in Perth, Western Australia (Tulloch & Fieldhouse, 1994; McKimmie, 1995), it is imperative that these inhibitions are overcome (Arnold & Peter, 1994).

Cameron & Barratt (1992) suggest the need for researchers to review contemporary learning theory, and to refine the chaining of concepts from short-term memory into long-term memory when designing computerized learning devices. This philosophy may be met by the chronology of computerized learning expressed by Reeves (1992a & 1992b), who states that to be effective, learning by computer must take place over periods of up to an hour or more at any one time, rather than minutes. At a minimum, the time sequence of interactive learning may not be less than 15 to 20 seconds (Ellis, 1994). To overcome flaws in the preparation of educational software by courseware designers, Uden (1994) recommended use of a methodology known as GOMS, an acronym initiated by Roblyer (1988), who applied it to outline the Goals, Outcomes, Methods and Strategies of learning.
2.14 Reservations and questions raised

Despite support from the literature and empirical observations, reservations remain about the use of computer-assisted learning (Richards, 1989). Although the efficacy of CAI is substantiated in medical education (Ashwood, et al., 1986; Branch, et al., 1987; Florey, 1988; Harkin, et al., 1986; Hmelo, 1989; Levine, et al., 1987) and its value verified by meta-analysis (Kulik, et al., 1986; McKenna, 1993), varied questions are raised about its educational validity (Prentice & Kenny, 1986; Roblyer, 1985). The mere availability of interactive multimedia does not guarantee learning (Clark, 1992; Henderson, 1994; Karpatschof, 1991; Loomis, 1992; Reeves, 1992a; Romiszowski, 1992; Richards, 1989). Perhaps the value of interactive learning created for interactive multimedia lies in the quality of its preparation by those who develop it. According to Clark (1983), the effectiveness of computer-based learning may be enhanced by the teacher being involved in experimental and control groups, arguing that more effort goes into the preparation of objectives with a comparable increase in learner performance. Similarly, Clark and Leonard (1985) reinforced the same aspect when discussing the effectiveness of innovation in teaching when using computers. These authors made the assertion that its effect is more likely to be influenced by the quality of its preparation rather than the innovation of its technology. However, this objection may be answered by the origin and style of those involved in the educative process. Traditionalists are schooled in the preparation of learning objectives, in which it is necessary to set out a statement of learning objectives at the beginning of a course, to be correlated with measurable behavioural changes at the end of it (Bloom, 1956; Krathwohl, Bloom & Masia, 1964; Mager, 1966). Unless the educator is clear about the content, method of
delivery and techniques of evaluation to be presented in any course of
instruction, it is quite clear that a fog of confusion will occur in the
mind of the learner, no matter what the technology. Naturally, this
problem may be overcome by adoption of a developmental model
which integrates major educational themes, such as the action learning,
and the competency based approach espoused by Mumford (1993). This
situation can also be redressed by adoption of a problem-based style of
learning, integrated with case-studies, blended in an interactive
computer managed environment, a view supported by Barrows (1983
Andrews, Schwarz, and Helme (1992), Lambert (1992), Reeves

In a critical exploration of social theory and moral issues related to the
use of computers in higher education, Williams (1994) articulates the
concerns identified by Lewis (1955) who, in science fiction, forecast
the mechanisms of downfall in an English university. Lewis developed
a theme of gadgetry, with interlocking coloured lights called a
pragmatometer (computer) to subdue reality and the desires of men. In
this way, Williams develops concerns about user-friendly software
which may become an hegemonic spirit of indoctrination to generate a
technicist mindset in a world of objects, rather than a process of
personal growth to knowledge, self-discipline, and wisdom. To counter
the risks of radical reconsectivism in education (Hebermas, 1984;
Taylor, 1990; Tobin, 1991) Williams recommends the use of learning
journals by students combined with strategies of interactive lecturing,
to ensure retention of personal values by self-disclosure in an
atmosphere of cultural enrichment.
Despite a plethora of literature and empirical observation which supports the use of computer assisted learning, reservations are still expressed about its application, especially by those concerned with the Hawthorne effect of Roethlisberger and Dickson (1939) associated with the computer-generated feedback strategies of Richards (1989). Andrews, Schwarz, and Helme (1992), claim that until the time of their publication, little had changed in the education of health care professionals during the past half-century. In addition, according to Browser and Sheperd (1991), only a small number of students are interested in technology-driven courseware, and Smeaton (1991), who considers that hypertext instruction will never replace interactive teaching. From this, it is clear that there is continual need for vigilance and research to validate and rationalise innovative methods of interactive learning at the tertiary level (Lee, 1994).

2.15 Metacognition to potentiate learner control
As already established, the quality of learning from any media may have little to do with the media itself. Instead, it is more likely to be related to the design and presentation of its content (Clark, 1983). The main advantage of computer-driven learning technology is its ability to present information in a consistent manner to large numbers of people (Clark, 1985a, 1985b). The cognition of learners, especially at the introductory level of an unfamiliar subject, is likely to be affected by inaccurate self-assessment of comprehension, terminating the process of instruction unexpectedly (Garhart & Hannafin, 1986). With the advent of computer-driven interactive self-paced learning, such peremptory withdrawal from the process may be less likely (Tobias, 1988). Further, if a model of independence is inculcated into the learner by provision of the ability to monitor a personal rate of progress by
computer-driven strategies, the quality of comprehension may be deepened by improved rates of learning (Hooper & Hannafin, 1991).

With careful preparation and variation of style to avoid boredom or conflict for the independent learner, metacognitive strategies can be embedded in the learning materials to intermittently prompt the recall of previous information (Derry & Murphy, 1986). In this way, the effectiveness of computer-assisted learning may be potentiated and reinforced by covert and overt learner control (Cameron, 1994; Hooper & Hannafin, 1991; Lee, 1994; Lee & Cameron, 1994; Reigluth & Stein, 1983).

2.16 The electronic campus

To facilitate the production of lecture materials to promote learning, more educators are turning to computer-based products to increase the impact of their presentations (Kuzmin, 1991; Troxell, 1993; Ee, 1994). According to Ee (1994), this is referred to as 'lecture automation'. Press (1991), used lecture automation techniques in classroom research at California State University, to affirm that students can obtain better scores by its use rather than without it. Whilst innovative educators use these methods, often referred to as the 'computer classroom' (Kettinger, 1991), others are beginning to question whether universities are really necessary (Brimelow, 1993) and suggest that they may be replaced by a concept termed the 'electronic campus' (Castleford & Robinson, 1994; Gardner, 1989; Henderson-Lancett, 1992).

According to Henderson-Lancett (1992), there is a distinct thrust towards the electronic campus espoused by Gardner (1989) and Castleford & Robinson (1994), in the UK, USA, and Australia.
Notwithstanding a convergence of libraries and computing centres, Henderson-Lancett (1992) asserts a continued need to re-engineer computerized educational strategies and course content to enhance teaching and learning.

While contemporary schools and universities still have reason to provide traditional teaching and learning situations over set periods of semesters, Bates (1993 & 1994) identified a technical and economic revolution taking place and a reduction of full-time campus-based students, with 63% of all university enrolments in British Columbia already registered as part-time in 1992/93 (B.C. Ministry of Skills, Labour and Training, 1993). Furthermore, Bates predicts, that even full-time campus-based students will be difficult to differentiate from those who are classified as distance education students within the next few years. In the long term, students will be able to access information and communicate with other lecturers, other students, and other types of multimedia via telecommunication networks from home and the workplace. In this way, learners will be able to access information from anywhere in the world.

In a preliminary review of student perceptions and access to increased educational technology for distance education, Boyd, Fox and Herrman (1994) developed and administered a questionnaire to a population of 2,500 students. In an Australian environment which advocates an increased access to higher education at a reduced cost (Ashendon, 1987), it is presumptive that students actually want this technology to be part of their learning process (Browser & Sheperd, 1991). In response to this philosophy, Boyd, Fox and Herrman developed a survey to ask questions about access to 24 different types of learning.
technology. Namely, to assess the impact of, radio, telephone, fax, audio and video recorders, television, videoconferencing, computers and computer software, and CD-ROM. Questions were also raised to elicit student perceptions about the value of this technology to them, and the most difficult aspects experienced when using it. A total of 887 (35%) responses were gathered, which were noted, categorised and tabulated to show trends in different professional disciplines. From these results, important issues of access, isolation, the availability of appropriate learning materials, and how to use these technologies were identified. Access to the technology seemed to be the most difficult single issue, with one in four students revealing difficulty with how to use the technology in the first place, followed by problems of location and availability of appropriate learning experiences. A sense of isolation was shown by 18% of respondents, with a plea that the technology was not being used properly. Fifteen percent of students commented that the time taken to learn to use the technology was a disadvantage, magnified by the time taken to get to an approved learning centre by rural students. Eleven percent of students declared that these technologies didn't coincide with their preferred learning style. Although discrepancies were shown between academic disciplines, students from the School of Business favoured increased use of computers, whereas distance education students from the Schools of Nursing and Social Science demonstrated a dislike of technology and associated stress by having to use it. It is noteworthy that these comments do not concur with the findings of Artus and Keenan (1994) discussed under the heading of CBL in Nursing, who have been successful in their use of learning technologies to encourage mature-age nurses to return to the workforce in Western Australia. No doubt this aspect would be supported by Boyd, Fox and Herrman, who also
identified inherent differences and expectations between students from different schools. Business students were more concerned about access to computer technology, and less about the availability of tuition. Conversely, Nursing and Social Science students, who tend to represent older age groups in distance learning situations, were more concerned about the presence of tutors and group support during adjustment to these new educational technologies.

The above scenario contrasts markedly with a review of two initiatives in United Kingdom national programs to promote the use of computer-based teaching throughout higher education by Castleford & Robinson (1994). The first phase, a Computer Teaching Initiative (CTI), entailed a suite 139 individual software-production projects between 1985-9, which failed to meet expectations. In 1989 CTI was redeployed as a network of subject based centres in support of information technology (IT) within particular academic disciplines. Coincidental to wholesale changes in a national reorganisation of higher education in 1991, a second phase of courseware was developed, entitled the Teaching and Learning Technology Program (TLTP) involving single institutions and consortia. In their conclusions, Castleford and Robinson (1994), outlined administrative and academic difficulties with the implementation of the initiatives during the first phase, with identification of the needs for change in the second and continued commitment to CBL until at least 1999 for a positive outcome in the future.

To demonstrate the value of paperless lectures, Burton and Wynn (1994) reported that computer-based technology has now matured to a point where it is less expensive to prepare and present lecture material
from the desktop than use traditional methods. Undoubtedly, many contemporary lectures are being prepared for presentation by computer driven technology, but this method is regarded by some as too time consuming for everyday use. However, this no longer needs to be the case. Burton and Wynn perceive no need for the use of photocopied graphic images, or text, for presentation by overhead projection; or any further need to store these images for retrieval and presentation at repeat lectures. Hence, the portability, mobility, economic and ecological advantages of paperless lectures are immense. According to these authors, when properly installed, lecture rooms become extremely efficient. The paperless lecture theatre requires either access for individually owned laptop computers, or provision of hardware at lecture work stations. The advantages of this approach are enhanced in team teaching situations, where overhead projections, or slides, no longer need to be reproduced in multiple copies, but instead, the entire presentation can be delivered to each team member, or directly to the lecture work stations. In the same way, handouts and notes can be made available to students who may then arrange self funded copies. The main disadvantages to this method are that staff members may lose track of sequential events in the unfolding software, and that there may be loss of apparent student engagement by eye contact due to diminished lighting. Student reactions to these lectures is commensurate to the quality of their preparation and presentation. Student criticisms of traditional lecture materials are related to the quality of its preparation, usually each screen contains too much information with unreadable print. Student-lecturer perceptions are invariably governed by these interactions. Accordingly, Burton and Wynn make it clear that electronic presentation will not endow an otherwise dull presentation with attractive learner appeal. These
perceptions coincide with those of Marcus (1992), who recommends a careful filtration of managed information at a suitable pace for learners. The findings of Marcus (1992), and Burton and Wynn (1994) concur with those of Lee (1994), who advocate a comprehensive use of multimedia to present and evaluate a computerized deployment of core material, to empower students by freedom of access to explore higher orders of thinking and learning.

2.17 CBL in Nursing Education

CAL has been in use to educate health professionals since Bitzer pioneered CAI in nursing courses via PLATO. PLATO is a computer-based education system which began at the University of Illinois in 1963 and 1966. These studies were followed by a project which adapted nursing materials in a computer-based teaching system to study variables of the process related to student achievement and self-directed learning. The content included a complete course of maternity nursing and eleven lessons in pharmacology presented via PLATO (Bitzer & Bitzer, 1973). In this study, over 300 nursing students were provided with a combination of tutorial-inquiry with pictorial and graphic information, which processed responses to give immediate results. Surprisingly, these authors showed immense foresight in the selection of objectives of this project which was designed to meet the challenges of expanding healthcare programs, shortages of nurses, changing roles, and problem-based learning in an environment of technological innovation. Staff and student feedback were incorporated with laboratory test and re-test exercises included in this project. From the results, the authors were able to affirm that students can learn nursing topics successfully and efficiently, concluding that students taught by computer can learn the same material presented in a classroom as well,
or better, in one-third to one-half of the time. From this early study, it is quite clear that it enabled staff to be released from the onerous tasks of marking and grading examinations. In this way computer-based systems can be used to dispense and test the absorption of information, leaving staff members free to interact with students and manage other forms of learning.

In an effort to update the profile of computer-assisted instruction in baccalaureate programs, Hebda (1988) used a carefully constructed questionnaire sent by mail to 441 accredited nursing programs. In this study of CAI, information was sought about inductive, deductive, didactic, guided discovery, discovery, inquiry, and problem-solving behaviours advocated by Gow (1976) for comparison with drill-and-practice exercises, problem-solving, simulation and tutorial behaviours listed by Berkell (1984). Of the 339 (76.9%) of those who responded, 164 (48.4%) indicated CAI use. Of these, 56 (16.5%) identified CAI use prior to entry to nursing courses, with 151 (44.5%) affirming CAI use in nursing courses. Simulations were in heavy use, together with problem-solving as a preferred method (Stewart, 1990; Lee, 1994).

These studies were followed by a successful field testing of flexible computer-assisted learning programs to supplement traditional unit instruction for undergraduate nursing students (Bratt & Vockell, 1986) and an exploratory study which analysed the individual characteristics and attitudes related to computer-assisted instruction in psycho pharmacological nursing (Paulanka, 1986).

Despite observations of computer-anxiety, or cyberphobia (Khoo, 1994), experienced by first year university students (Clarkson &
Pollock, 1993; Henderson, 1994; Volet & Styles, 1991), most computer-assisted nursing studies report computer-effectiveness in comparison with traditional methods in terms of achievement at examinations (Bitzer & Boudreaux, 1969; Conklin, 1983; Hannah, 1979; McKenna, 1993) with a retention of positive attitudes towards computers throughout (Kirchoff & Holzemer, 1979; Morin, 1983; Schleutermann, Holzemer & Farrand, 1983). According to Belfry and Winne (1988), nursing students tend to show positive attitudes toward computer-assisted instruction, especially when the information is perceived to have value and is regarded to be in advance of current textbooks (Kirchoff & Holzemer, 1979).

In support of innovative teaching and learning technologies, O'Connell and Herrman (1994) cited the advantages of computer-assisted learning already established in nursing education. These included the initiation of active, rather than passive learning (DeYoung, 1990) which coincides with the views held by Reeves (1992b); the encouragement of problem-solving activities in a risk-free environment (Klaasens, 1992), supported by Stewart (1990), Lee and Allison (1992), and Lee (1994); the application of a multiplicity of learning styles which can be audited by academic staff (Schmidt, Cohn, Gaston, & Boonie, 1991), an aspect under research by Lee (1993 and 1994). Furthermore, O'Connell and Herrman (1994) outlined other important points to overcome the weaknesses of courseware identified by Farabough (1990). Namely; a need to empower students to control their own rate of learning whilst enabling them to bypass previously learned material; the use of positive reinforcement loops which direct the learner through a remedial sequence; placing a limitation upon superfluous information and
graphics on each screen; and a limitation of 30 minutes to any learning program.

To rationalise the daunting task of presenting and marking microbiology units to 600-700 students each year, Courtney and Edwards (1993) used computer-managed-learning (CML) programs for the purpose. Previously, the marking and assessment of this unit had been labour intensive, confounded by complaints by students who perceived inequalities of questions given to individual groups of students. To meet these goals, learning objectives were identified and developmental steps organised to meet well defined criteria. From their experiences, the authors were able to enunciate the advantages and disadvantages of the system, as well as student and staff perceptions of CML. The main disadvantages to learning microbiology by CML identified by staff members, is that it is extremely labour intensive in its development and preparation. The main disadvantages identified by students were related to those who use English as a second language, namely, that CML questions in microbiology are sometimes difficult to understand, compounded by complexities of security to protect the database. However, the advantages of CML reveal that 20% more time was gained by staff members, which enabled them to conduct more relaxed classes, with additional time for discussion and application of the knowledge. Overall, students appreciated the creation of more objectivity and uniformity in the presentation of questions, together with the availability of immediate feedback from questions, and opportunities for independent learning.

In the same way, Edwards and Fox (1993) developed a prototype CAL program for the delivery of general medical science to nursing students
in a problem-based environment. Case studies had previously been used for smaller numbers of students, but with a rapid expansion of unit size to 600-700 students, hypertext was used to link validated studies to an enlarged database; a view shared by Kozma (1991). In this way, clinical simulations and case studies were prepared to provide opportunities of self-directed learning. Because a proportion of their students were from distance education sources, Edwards and Fox used a basic HyperCard platform, which could be converted to colour later. Furthermore, these authors adapted and modified the criteria of Gygi (1989), Schneiderman and Kearsley (1989), Kozma (1991), and Smeaton, (1991), to develop user friendly, flexible, software as an evolving shell. In this way, Edwards and Fox planned to avoid unrelated superfluous information and minimise interference with the learning process. Nevertheless, after obtaining evaluative feedback from staff and only nine out of 200 students, Edwards and Fox conclude that although the students found the computer database useful, they do not believe that hypertext instruction will ever replace face-to-face teaching. In addition, at the time of publication, this team of software developers, namely, the subject expert, instructional designer, programmer, and graphic designer, had spent approximately 450 hours on the project, which was still not to their liking. This raises issues to be dealt with under the heading of cost-effectiveness and the value of complementary methods to enhance learning (Canale & Wills, 1993; Glaister, 1994; Lee, 1994).

In a profession which requires 100% clinical accuracy during the calculation of dosage when preparing medications, Glaister (1994) used the andragogical principles of Knowles (1970; 1984) and Smith (1991) to introduce computer-based learning packages to attain this level of
mastery by nursing students at Curtin University. Glaister cited the alarming dosage errors identified by Worrell and Hodson (1989), which demonstrate that 56% of registered nurse drug errors may result in a tenfold variation rate above, or below, the level prescribed. In a non-threatening environment along the lines proposed by Knowles (1984), dosage calculations had previously been taught by lecture presentations, reinforced by practical worksheets to reach an acceptable level of competency throughout the semester. However, in a teaching-learning environment of increasing expansion and diminishing resources, a review of this process was considered necessary. To address the problem, Glaister took note of previous student performance in dosage calculation tests. Results from the period 1989-1991 indicated a mean mastery rate of 46% achieved on the first attempt by students in their third semester. Therefore, better options were considered necessary to engender safe practitioners. In a philosophy of active student-centred learning with adult themes, a literature search showed support for the development of a computer-based learning program to deal with dosage calculations (Cartwright, 1987; Reynolds & Pontius, 1986; Thiele, 1986; Wong, 1990; and Worrell & Hodson, 1989). A core team approach was taken, centred around the content expert and computer programmer. Four learning modules were established, in which preparation time proved to be more labour intensive than for traditional presentations. A basic time of 110 hours was recorded for development of the first two modules in lieu of two hours of teaching, a ratio of 55:1. However, significantly more hours were spent in the modification of these presentations in a suitable mode. The modules were prepared for presentation on an Apple Macintosh computer, initially using Aldus SuperCard 1.6 with screens supplemented by MacDraw, Photoshop and Canvas, which were later
advanced by graphics and animation by MacroMind Director. A trial of the prototype was introduced to all third semester students, who attended a one-hour preparatory session to acquire rudimentary computer skills. An evaluation questionnaire was also developed, using Likert scales and open ended questions, to obtain formative data to assess student reactions to; instructional design; user interface; content; presentation; and satisfaction. Although the results of Glaister's initiatives are yet to be analysed, reactions to its implementation are reportedly favourable. The author estimates an increased quality of presentation, with a decrease in demands made upon staff, whilst third semester nursing students learn to master dosage calculations by computer. Furthermore, students became more active during this learning process, with a 1993 competency rate of 57.5% for the first attempt, compared to 46% in 1989-1991. Although this program has taken two full years of development, further investigations are indicated to improve its technical design and determine its cost-effectiveness.

To assist nurses to return to the workforce in Western Australia, a computer controlled refresher course was adapted from the Grant MacEwan Program in Edmonton, Canada. Since 1983, this program has been used for the re-accreditation of nurses in Alberta. In August 1987, a team from the School of Nursing at Curtin and other healthcare agencies, reviewed, modified, and adapted the Alberta program to meet the needs of distance education students in Western Australia. Artus and Keenan (1994) reported the successful progress of this program, together with the results of an evaluation by some of its students. In essence, general and midwifery programs are coordinated from the School of Nursing at Curtin and the Australian Institute of University

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Studies at Joondalup, which regulate distribution to eight widespread rural Learning Centres. In this way, peripheral students at the Learning Centres are linked to a Learning Management System of software by Outspoken, a telecommunications mechanism, to access the mainframe VAX 11/750 in the two metropolitan centres. On entry, each student is orientated to the resources and expectations of the program by a tutor. From this, the student determines an individual rate of progression, which is written up as a learning contract. In this way, selected modules form a framework of sequential studies, which contain posttest material. Once satisfied with their own rate of progress and achievement whilst learning, the student arranges to go to a nearby learning centre to undertake a supervised, computer-driven, multiple choice test. The required pass rate for these tests is 80%. If this is not met, a scheme of remediation is advised before taking the test again. In this way, a system of mastery learning is applied until a successful outcome is achieved. According to Artus and Keenan (1994), this model of computer managed learning is similar to that of Van Breugel (1991), who uses traditional media, such as books, videos, laboratory sessions, and tutorials, which are computer managed in a self-paced environment. In conclusion, Artus and Keenan assert that this is a flexible method of distance education, from which its graduates are well received by employers. Furthermore, feedback from students has been favourable, whilst at the same time providing sufficient professional skills to enable them to return to the workforce.

2.18 CBL in Dental Education
CAL is well represented in dental education by the Flexible Dental Curriculum at the University of Kentucky in 1971 (Mast & Watson
1976) and at the University of Manchester by Levine, Jones & Morgan in 1987.

In the Manchester experiment, an intake of 60 first-year dental students was evenly divided into two groups to learn the pathology of dental caries and periodontitis. In a cross-over design, dental caries was taught by computer-assisted learning (CAL) and periodontitis by tutorial teaching (TT) to one group and in reverse order for the other. Objective testing and a follow-up questionnaire was applied to both groups, to show that both methods were equally effective. Further investigation of the questionnaire results indicated a sense of pressure from the CAL experience and problems with note-taking. Nevertheless, Levine, et al., were able to affirm CAL to be more cost-effective in terms of staff involvement.

With dental practices in the United Kingdom increasingly becoming computerized and a commitment by the Dental Practice Board to ensure that the majority of practices will be computerized within the next few years, Pollard and Davenport (1994) outlined a project to evaluate CAL programs as distance learning packages for dentists. Four CAL modules were developed from chapters in a textbook, with user feedback as a basis for the correct answer. Sixty-five dentists were recruited as evaluators in private practice and dental schools. All participants completed a questionnaire consisting of fixed and open questions, ranked on a scale of 1-5, representing 1 as a most negative response and 5 as a most positive response. Results indicated that CAL modules took 10-45 minutes to complete. Positive responses to the questionnaire were: 85% found the CAL programs easy to use; 78% reported that the programs extended their knowledge of the subject.
The CAL modules were reported to be more useful than audio tapes (83%), journals (74%), videos (66%) and books (65%); 80% were interested in CAL programs; 64% declared they would purchase the CAL packages. Negative responses were: that only 43% considered the programs to extend their practical clinical skills; 30% were frustrated by invisible target zones being too precise; a few suggested that the clarity of text and diagrams could be improved.

2.19 CBL in Medical Education

The contemporary medical school curriculum has been questioned in many areas, with concerns about course construction, content, presentation, independent learning and student evaluation (Barrows, 1983; Anbar, 1987; Barker & Yeates, 1988; Warner, 1989; Lambert, 1992; Andrews, Schwarz, & Helme 1992). Some of these problems are addressed by computerized learning taking place in medical schools evidenced by Holley and Heller (1984), who compared the use of microcomputers with tutorials to teach anaesthesiology and Harkin, Dixon, Reid, and Bird (1986), who used computer driven microfiche, slide projectors, and objective questions for an interactive presentation of pathology.

In an environment which accepts that traditional methods of medical education can be augmented by self-directed computer-assisted learning, Kidd, Hutchings, Hall, and Cesnik (1991) used hypermedia to develop a program of learning to deal with the clinical management of sexually transmitted diseases (STD's). These authors used StackMaker, a set of specific authoring tools, to launch learning materials and case studies related to STD's. StackMaker had been developed previously to present cell biology units to undergraduate biology students (Hall,
Thorogood, Sprunt, Carr, & Hutchings, 1990; Hall, Hutchings, Carr, Thorogood, & Sprunt, 1991). The end product was successfully delivered in a non-linear format, accessed by a multiplicity of nodes, for use by medical undergraduates, postgraduates in family medicine, and practising general practitioners.

According to Hutchings, et al., (1992), comprehension of biomedical sciences cannot be achieved by learners without dynamic access to graphic information. Such information cannot easily be projected in lectures, or be found in textbooks, therefore, these authors advocate such learning by interactive multimedia. Furthermore, they subscribe to the concept that medical education requires an intuitive pattern of reasoning from disparate facts in order to link diagnostic information, or detail from radiographs during surgical procedures.

In a paper which described the development of CAL to teach pathology to medical students Harkin, et al., (1986) declared that computers make excellent teachers to present information in a logical manner which can be monitored, virtually without mistakes or boredom. These authors were already committed to advanced styles of teaching and learning, evidenced by 'self-help' problem-solving exercises, slide-tape units and poster demonstrations which were incorporated into the computer system (Lee, 1994; Pollard & Davenport, 1994; Stewart, 1990). The computers were used to display text, graphics, multiple choice questions and open-ended textual questions. Visual images were provided by computer controlled random access to microfiche and slide projectors, which displayed morbid anatomy and histopathology within a time span of 2 to 7 seconds. Textual display was described as statements of factual information composed of up to 19 typed lines,
each of 39 columns. The multiple choice question tests followed the Newcastle medical school format, each with a stem and five optional responses, each option to be answered separately, which may be true or false. The marking scheme gained one point for a correct answer, lost one point for an incorrect answer, with a score of zero for a 'don't know'. Open-ended text questions required the student to type in a short answer. These questions were programmed to accept and score keyword responses, such as 'what type of necrosis is seen in tuberculous lesions?', the answer being 'caseous'. Other examples were given with paired responses such as, Crohn's disease, regional ileitis; or numerical responses to cover peaks of incidence in an age range. The authors rejected random access to videotape materials because of the time it takes to rewind to the appropriate segment and consequent loss of an illusion of immediacy. Video-disc operation was considered as an option, but rejected on the grounds of cost and that it could not be updated or modified by superimposed recordings. The project initially involved the preparation of 20 programs by 11 staff members, each of whom was responsible for the total creation of one or two modules. Astoundingly, these authors declared that the construction of each program took place in a short space of time, 'approximately in an evening's work'. Upon reflection, this appears quite feasible because the visual images, open ended questions and multiple choice questions, were already master programmed and at call by an index number. Furthermore, the time taken to 'master author' the computer system took less than one hour. Hence, the programs were immediately available for use by the students. Feedback from the students was enthusiastic without sign of 'computerphobia' with work stations in use during previously 'unsocial' times, such as lunch hour, evenings and weekends. Records were kept to show a constant work station use of
30-40 times per day. Although it was anticipated that students would operate individually, in a truly open learning situation it was observed that students gathered in small groups to answer questions on a consensus basis, with a volunteer operating the keyboard. Unfortunately, feedback from students was merely left to a notebook in the computer area, which was somewhat subjective, reporting complaints that questions were too easy, as well as containing ambiguity and typing errors. In the same way, no supporting data of any results or achievements was given to assess rates of learning throughout this otherwise interesting project.

Florey (1988) developed and applied a questionnaire to survey the use of CAL in 31 British medical schools in which he elicited information about medical school policy and departmental use of hardware and software. Out of the 31 questionnaires sent, only 20 school questionnaires were returned in which 72 departments in 17 schools gave detailed information about 172 CAL programs already in use. From these responses, it became clear that there was no clear policy for CAL use at that time, nor were developments under way to expand its use. However, upon further scrutiny of the results it was possible to identify commitment by separate departments, particularly in preclinical areas. In conclusion, because of stretched financial resources, Florey recommended inter-medical school and inter-departmental collaboration for the development and distribution of resources to rationalise costs.

Wigton, Poses, Collins, and Cebul (1990), applied computer-assisted instruction to improve the judgement of experienced student-health physicians by using simulated patients with pharyngitis. These authors
used simulated case-studies over a 6-month period of educational intervention and the use of 'cognitive feedback'. Cognitive feedback was described as predictive computerized cues to enhance performance by giving clinical information when forming simulated judgements. From these results, Wigton, et al., (1990) were able to demonstrate a rapid increase in clinical performance by computer simulations.

To compare CAI supported by graphics and digitised sound with small-group instruction to sharpen auscultation skills by third year medical students, Mangione, Nieman, Greenspon, & Margulies, (1991), randomly divided a volunteer group of 42 students into three groups. To exclude the risk of a Hawthorne effect, volunteers were informed that no extra credit would be given for participation in the study. The group nominations were; to a small seminar-lecture group (I); to CAI group only (II); to a small seminar-lecture group and CAI group (III). Once assigned, no changes were permissible. The CAI selected was the commercially available HeartLab, developed by the Computer Science Division of Harvard Medical School (Dean, 1987). In effect HeartLab is a user friendly sound synthesiser which represents an assortment of murmurs, clicks, snaps, gallops, sounds, rates, and rhythms. These auscultatory phenomena are either presented separately, or in combination with one another, each accompanied by appropriate clinical graphics driven by an Apple Macintosh computer. All participants took a pretest consisting of eight cardiac events recorded from a pool of 250 sounds. The eight sounds were recorded on a HiFi cassette deck and relayed by simulated stethoscopes (Stethophones). Ninety-four multiple choice questions about each of the eight events were constructed to evaluate the presence, or absence, of selected clinical characteristics. After the pretest, groups II & III were given a
15-minute demonstration of how to use the CAI hardware and software. The computer lab was made available to groups II & III on a 24 hour a day basis; group I was excluded from the computer lab. It is significant to note that the computer lab was coincidentally located within a three minute walk to a nearby medical ward for clinical reinforcement. Groups I & III (seminar-lecture and conjunctional CAI groups) were given a 90-minute audiotape of the synthesised sounds generated by HeartLab. Throughout, with the exception of exclusion to the computer lab by group I, all 42 students were allowed free access to all other conventional sources of learning, including patients, teachers and house staff members. Groups I & III met for a one hour seminar per week for 3 weeks. Its content was arranged to coincide with that available to the CAI group (II). At the end of a 6-week rotation, all students took a posttest, which was identical to the pretest. Pre and posttests were scored as a percentage of the 94 multiple choice questions answered correctly, incorrectly or left blank. Of considerable interest was the inclusion of a diagnostic score of 17 'pathognomonic' questions (which Underwood (1992) defines as the ability to make judgements from distinctive and specific characteristics of a disease). At the end of the study, the CAI groups (II & III) were asked to complete a 38-item questionnaire to assess the impact of student participation, preference for CAI versus tutorial teaching, and computer anxiety index (Orr, 1988). Analysis of covariance was applied in which pretest scores were classified as covariate and posttest scores as the dependent variable. Since an analysis of covariance does not provide an overall indication of improvement, repeated measures by ANOVA's were also performed. ANCOVA's and ANOVA's were performed separately and together for the 17 diagnostic test items. Thirty-five of the 42 participants completed the study, thirteen of
whom belonged to group I, nine to group II, and thirteen to group III. Neither ANCOVA nor ANOVA measured any significant differences between the groups, nor did the pathognomic diagnostic tests. There was no significance in the time spent by groups I and III on the audio cardiac tapes, whereas there was a strong trend towards significance in the time spent by the CAI (II) group. There were significant differences in response between group II and III to the computer anxiety index, with the CAI (II) group demonstrating a significantly high level of computer anxiety as well as a significantly high preference for CAI. Furthermore, there were significant differences between groups II and III regarding the efficiency and preference for CAI or lecture-seminar teaching. Group II was in opposition to group III, considering CAI to be more efficient than group III. Certain subjective group loyalties appeared to prevail, with groups I and III in favour of lectures and small-group teaching, whilst group II favoured CAI being unaffected by there being no credit for its use. It was noteworthy that the authors admitted that their study groups were too small to provide data of real significance, referring to Cohen (1969) where at least 42 subjects per group would be required to detect an optimistic medium size effect of 6% of the variance, whilst a small effect representing 1% of variance would require 258 subjects per group for 70% power, and 322 subjects per group for 80% power. From these findings, the authors conclude CAI to be at least as effective as conventional teaching for medical students.

According to Biran & Biran (1986), computer-assisted learning provides opportunities for students to acquire meaningful information at their own pace, or in small groups. Furthermore, independent students can enhance such learning by problem solving in a computer
driven environment. Kidd, Cesnik, Connoley and Carson (1992) advocate the use of CBL in medical education to learn new material and apply previously learned topics in risk-free clinical simulations without jeopardy to the health of live patients. In this way, medical students can learn by taking risks in contrived simulations, gaining positive feedback from the programs to determine the consequences of their actions (Andrews, Schwartz, & Helme 1992; Pickell, Medal, Mann, & Staebler 1986; Wigton, 1987).

To reduce the size of the information explosion and overload to digestible proportions, Andrews, Schwarz, and Helme (1992) assessed the effectiveness of a computer-assisted learning program used by fourth-year medical students whilst studying dementia. To complete this investigation a cohort of 141 fourth-year medical students took place during a standard curriculum of two-weeks related to geriatric medicine. One hundred and thirty-eight students completed the study, a group of 65 (38 male and 27 female) were arbitrarily assigned to a computer-assisted learning program, whilst the remaining 73 (41 male and 32 female) received similar material by tutorial. The computer-assisted learning program was presented as an interactive case study with vignettes to cover the diagnosis and management of patients with dementia. The tutorial consisted of two authenticated video programs together with discussion of issues related to dementia by a geriatrician. With the exception of three subjects, the outcome was measured by achievement in a pre-posttest regime in the form of a previously validated multiple choice questionnaire. The pretest was administered on the first morning of the course and the posttest was taken on the final morning of the course. At pretest, the computer learning group obtained a mean score of 66% with a range of 64 to 69% and the
tutorial learning group also achieved a mean score of 66% with a range of 63 to 67%. No significant differences could be identified between the two groups at pretest, verified by F1, \( 136 = 0.61, P = 0.61 \). At posttest the computer group achieved a mean value of 81% with a range of 79-83%, whilst the tutorial group obtained a mean score of 74% with a range of 73-77%. Clearly at posttest there was a significant difference between the two groups, evidenced by F1, \( 136 = 21.83, P < 0.001 \). The authors cited Roblyer (1985), who classified effect sizes of 0.2, 0.5, and 0.8 as evidence of small, medium, and large teaching effect results respectively, to demonstrate a large teaching effect in their own results, where the computer group gained an effect size of 1.42 in comparison with an effect size of 1.10 achieved by the tutorial group. From these data it can be observed that both groups increased their level of knowledge of dementia during the prescribed two-week course, with the computer-assisted learning group showing the greatest improvement. By administration of a feedback questionnaire, these authors were also able to provide data to refute any perceived barrier to the acceptance of computer-assisted learning methods into the medical curriculum. With the exception of one student, the remainder had used a computer previously, not only as part of their medical course, but also for leisure activity or as a word processor in the preparation of assignments. Surprisingly, 50% of the students reported a history of computer programming. These findings coincide with a positive attitude towards computerized learning among medical, dental, nursing and veterinary students by Jones, Navin, & Barrie (1991). The collective assertion of these students reflects an enthusiastic belief by aspiring healthcare professionals that computerized learning programs are an essential component of their educational process (Andrews, et al., 1992; Harkin, et al., 1991; Lee, 1994 & 1995; Harkin, et al., 1986).
Despite these advances, Tessler (1989) identified a paucity of computerized instructional software for radiologists whilst Andrews, et al., (1992), claimed that little had changed in medical education during the previous half-century. These comments underscore the Luddite Mentality identified in postgraduate medical education by Lambert (1992). Although these criticisms may be countered by the development and testing of a prototype computerized patient simulator by MacDonald (1994), who reported successful field-testing on medical students, showing that computer-assisted learning is acceptable at the undergraduate medical level when testing diagnostic and therapeutic skills. More important, is the need for all health workers to become computer literate in light of the emergence of a computer-driven lifelong patient record keeping system, and the interpretation of its logistics by medical questionnaire, combined with clinical history taking for diagnostic purposes and research (Arnold & Peter, 1994).

2.20 CBL in Biomedical Education
Boyle (1985) demonstrated the value of microcomputers to teach respiratory physiology, whilst Ashwood, Fine, Beherens, and Adams (1986) emphasised the importance of visual information in computer-aided instruction when enhanced by video images, declaring that this combination has great potential for the education of laboratory technologists. It was acknowledged at that time that computers could not replace reputable textbooks, nevertheless, these authors were of the opinion that CAI could be adapted for tutorials, drill sequencing, simulations, and case studies for problem-based learning to supplement individualised learning. These findings supported the views of Adams (1985), who favoured the implementation of operative rather than figurative knowledge. Furthermore, Ashwood, et al., (1986)
emphasised the importance of visual images when learning about medical technology from atlases whilst teaching haematology, microbiology, parasitology, and anatomical pathology. To meet this end, a computer-controlled videodisc player was successfully applied to import and interactively drive such visual images. No instructional data was given, but these authors showed a significant insight into the needs of individualised learners and the potential of such enhanced technology for future use.

In an environment which questions the validity of using live animal experiments in some of the biomedical sciences, Branch, Ledford, Robertson, and Robinson (1987) used computer screens to introduce videodisc recordings to teach various categories of cardio-pulmonary physiology to 87 first-year veterinary students. The subjects were randomly assigned to either experimental or control groups. Learning activities were classified as controlled independent variables with performance in practical examinations as dependent variables. An attitudinal survey was used for comparative purposes. Both groups attended classes in which clinical heart sounds were heard and discussed. Both groups were also provided with copies of a record of canine heart sounds for independent use, and asked to complete an individual log when listening to it. This was reinforced by audio cassette tapes made from the videodisc master tape and placed in the library for check-out. During the first formal laboratory experience, the control group was exposed to the audio heart sounds, whilst the experimental group used the videodisc. Following this laboratory all students practiced auscultation independently, with the videodisc available to the experimental group only. Multiple analysis of variance was used to assess test score differences, with the time spent with the
media systems as a covariate of analysis. The total time spent on media by the control group averaged 304.89 minutes, with a standard deviation of 224 minutes, whilst the experimental group averaged 360.88 minutes, with a standard deviation of 187 minutes. When tested, the control group achieved a mean score of 81.32 minutes and a standard deviation of 16.8 minutes, whilst the experimental group attained a score of 83.26 minutes with a standard deviation of 19.0 minutes during the heart sound recognition test. Although the experimental group gained a mean score of 1.94% ahead of the control group, indicating no significant difference between the two groups, student responses from the survey were favourable to the videodisc. However, it is possible that the experimental group was influenced in their activities by the need to keep a written log.

The research of Branch, et al., (1987) is reinforced by findings from the ILAB (Interactive Learning And Biology) Project, commenced by Hutchings, et al., (1992) in 1989, using four videodiscs delivered by HyperCard related to cell biology containing nearly 100 film sequences with alternative commentaries in English and German (Brereiter-Hahn, Fischer, Hock, & Kiermayer, 1984). After evaluation of three successive cohorts of first-year undergraduates in Biology, Hutchings, et al., reported a generally agreeable reaction to the system, in which 93% declared that they were not intimidated by the technology, 80% enjoyed its use, 89% found it to be an effective learning resource, 88% found its content to be relevant to their course, and 93% stated that they would use it again as a general source of reference. Of interest, 40% of students in the third cohort found difficulty with navigation, saying it was easy to become disorientated when navigating through the system. As a result, the authors placed emphasis upon an index of

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material together with the development of a navigational map. From this it is clear that as the size of the database grows, so do the problems of identification of content by the learner. With the exponential growth of computers espoused by Gates (Appleyard, 1994), it is imperative that information providers remain vigilant and responsive to student feedback by tailoring tools of access to suit the task being performed (McKnight, Dillon, & Richardson, 1989).

Yochim and Dori (1993) demonstrated the value of intelligent computer assisted instruction (ICAII) to learn physiological principles. Initially, these authors used self-directed learning modules to enhance lecture materials in the presentation of information about the endocrine, digestive, and neurological systems. However, the ICAII materials proved to be so successful that they were used to displace lectures in favour of self-directed learning. In this way, Yochim and Dori developed a pattern of flexible stand-alone modules which enable self-paced learning whilst giving feedback about performance through interwoven quizzes and tests. A Card Traversal Graph (CTG) instrument was embedded within the courseware, not only to obtain information about learner usage, but also to evaluate learner reaction via an assessment questionnaire. The authors declared CTG to be a transparent companion to the user whilst it automatically tracks the order and duration of time spent learning on each screen. In this way, the CTG was used to analyse the learning path selected by learners and the time spent on each screen. Out of seven learning modules, Glands and Hormones, the core unit, attracted one fifth of the collective learner time, whilst three other modules received less than 10% each, and another unit only one percent of the time. Of greater interest, was that these techniques showed that 35% of the total time was being spent
by students trying to problem-solve their way through tests and quizzes. From this information, Yochim and Dori were able to redeploy test and quiz items, as well as simplify the descriptive appeal of the unattended units, resulting in an even distribution of attention in later observations. Using a projective style of open ended questions (Knowles, 1984) results were compiled in four categories; how I found the program; what the program did for me; how I used the program; and my overall impression. In a summary of these four-part responses; students declared the software to be well organised, that it was understandable and easy to use; that interest was captured in the subject; that there was a positive response in the ability to test their own knowledge; and that they would recommend the learning modules to their contemporaries.

2.2.1 CBL in Allied Health Education
Freeman (1987), surveyed the use of computers in 60 Allied Health education programs to find less than 50% usage up to that time. However, an increase in computer use was noted in the classroom, as well as in simulations and clinical education. Freeman concluded that CAI be used to provide remediation, reinforcement, enrichment, test-taking, drills, and didactic learning in programs. From this, Freeman strongly recommended an increase in computer use for Allied Health programs during the next decade. These observations coincide with those reflected in a twenty year review of computer-assisted instruction for health professionals by Hmelo (1989), in which she identified the need for more research and higher orders of learning and problem-solving techniques by CAI in medical, nursing and allied health education.
In two distinctive CBL projects Lee & Cameron (1994) reviewed the needs of individuals whilst navigating through interactive multimedia learning materials. The first of these projects was a multimedia database of recreational activities whilst the second described the development of a Student Operated Computer Controlled Educational Resource (SOCCER) in a Computer-managed Learning Environment (CMLE). Learners were provided with freedom of access to quality assured software and tests to explore their level of competence in discrete areas of a body of knowledge dispensed within the CMLE. The activities of learners and pathways selected by them were audited to provide data for assessment, evaluation and research. In the second case, learners were empowered to become self-paced and self-directed with an ability to control their rate of progress throughout the body of knowledge provided in interactive computer-assisted learning packages. Test and Feedback items were also provided to enable learners to determine their readiness for entry to formal test procedures.

2.22 CBL in Continuing Education

Three main areas of continuing education identified by Moore (1978) to perpetuate education among physiotherapy graduates focused upon the individual, the educational institution, and the professional association. The methods mentioned were entirely traditional, consisting of lectures, workshops, short specialist courses, conferences, formal post-graduate courses, private study, and the acquisition of knowledge from alternative resources. CBL for the continuing education of physiotherapists was not mentioned at that time. However, in a further scrutiny of continuing education for physiotherapists, Glendinginning (1982) cited Fleming (1976) to describe a professional and legal responsibility to 'measure up to the standard of competence of the
ordinary person professing such skills'. From this standpoint, Glendinning explored the difficulties associated with gaining participation, motivation, and the design and development of programs to meet the needs of professional members in isolated communities. To counter some of these problems, Glendinning recommended the advantages of relatively inexpensive computers and floppy discs for personal use, advocating mobilisation of existing in-service CBL training programs for private practitioners, either to 'clusters' of hospitals, or by extension into the home environment.

Coincidentally, the medical profession was experiencing the same dilemma in attempts to stimulate an ethos of continuing medical education (CME) by its graduates. Evidence for this was given by Laxdal (1982), who discussed the learning needs and program planning required by physicians, as individuals, or in small and large groups. To reinforce his argument, Laxdal quoted Knowles (1970), who declared: 'The highest expression of the art of the adult educator is skill in helping adults to discover their own learning needs'. Thus, Laxdal emphasised the vital role of CME to meet the perceived needs and assessment of its learners, recommending the use of a databank of diagnoses and problems delivered by computer to compare individual diagnostic methods with those of experts. At that time the participation costs of CME had increased rapidly over the previous decade, reaching $3 billion per annum in the United States (Knapp, 1981), with little scientific evidence to prove that CME affects the performance of its participants or the health and wellbeing of the patients (Bertram & Brooks-Bertram, 1977). To reach this conclusion, Bertram and Brooks-Bertram undertook a comprehensive meta analysis of the effectiveness of 66 publications related to CME.
Porter (1991), conducted a State wide study in Michigan for the continuing education of n=111 paramedics distributed throughout 11 defined learning centres to determine the relative effectiveness of lectures, video, and computer-assisted instruction. The average participant was identified as 32 years of age, with two years of post secondary education, having completed paramedic training by four years with 20 hours of continuing education in the previous year. Analysis of the posttest scores showed that the CAI subjects performed significantly better (79.6%) than the lecture (70.5%) and video (68.9%) groups. Of greater interest, was that when the same posttest was repeated 60 days later, the significant differences between the groups was maintained with retention scores of 70.9%, 59.4% and 59.1% respectively. The continued improvement of the CAI group was attributed to an increased familiarity and positive experience with the method. CAI students were empowered to explore the data screens at their own pace, which could be revisited as frequently as desired. Furthermore, CAI students were not permitted to proceed without provision of a satisfactory solution to reinforce each question. Thus, the CAI groups obtained positive reinforcement by sustained freedom of access to learning materials whereas the lecture and video groups were restricted by the pace of regulated presentations.

2.23 Learning anatomy by computer

In the 16th century, a famous Flemish anatomist, Andreas Versalius, published seven books to illustrate the structure of the human body. Not only are these books of historical significance, but they have also been used to commemorate the originator in the creation of a comprehensive 3-D anatomical database entitled the Versalius Project (McCracken & Spurgeon, 1991). In a description of the Versalius
project, Roper (1989), suggested it to be a major transformation in the field of gross anatomy, in effect an electronic version of Gray’s Anatomy, which combines the imaginative talents of anatomists with computer engineers, medical illustrators and educators. The Versalius Project gives more evidence of a combination of talents by medical illustrators and scientists to validate the prophesy of Mahoney in 1990, emphasised by the Anatomy Project (Abrahams, 1990; VanBiervliet & Gest, 1994) and the Electric Cadaver (Freedman & Chase, 1990). At that time these sources were reinforced by a burgeoning of similar systems in higher education, outlined by Kaplan-Neher (1990), exemplified by the Hippocrates Project in anatomy, physiology, and neuroscience developed at the New York Medical Center (Nachbar, 1990); computerized Chest Tutorials developed for medical students and residents via CD-ROM in NSW, Australia (Sendel, 1992); Basic Ophthalmology, a CD-ROM product from the University of Iowa, designed to teach medical students, physicians, nurses, and paramedics in the subject; Medical Human Anatomy, a program of multimedia currently being developed at the University of Kansas to add a new dimension of independent learning for medical students, using HyperCard, SuperCard and MacroMind Director, (Ash, 1992); Diagnostic Reasoning, an interactive user friendly HyperCard program designed to facilitate learning and evaluation skills in a problem-based environment of clinical problems for medical students (Myers, 1992); Human Brain Anatomy, a software introduction to brain anatomy in tandem with images from the Slice of Life, together with animations from videodisc and MRI for medical students (Davis, 1992); ADAM, an acronym for Animated Dissection of Anatomy for Medicine, and Eve, both of which provide a database of multimedia courseware to access information about human anatomy and medical terminology.
(Swayne, 1992). In essence, healthcare professionals can use these techniques for safe exploration in environments which would otherwise be expensive and dangerous to human life (Boyle & Doyle, 1992). Furthermore, it would appear that these developments have occurred either wittingly, or unwittingly, in response to the explosion of medical information identified by West (1990).

This explosion of information proceeds in continuum, as evidenced by the *Micron BioSystems*, which include interactive CAI and lazerdisc CD-ROM elements in histology, pathology, haematology, and the presentation of regional gross anatomy modules for the back, upper limbs, thorax, abdomen, pelvis, head and neck (Stoecker, 1994). Collectively, these projects present computerized dynamic textbooks of gross and microscopic anatomy, interlaced with histology, radiology and pathology, empowered as tools of dissection activated by cross-referenced video-data bases (Freedman & Chase, 1990; Roper, 1989).

In view of the exponential growth of knowledge, and that the study of anatomy is a visual and descriptive science, the consequent stress occurring among new students is observed to present problems with the absorption of massed information. From this, it is now clear that the time has come to focus students upon self-directed learning with provision for individual acquisition of information from an international database (Lee, 1994). On face value, it would appear that independent learners with well developed written, verbal and visual skills are more likely to overcome these difficulties. However, there is an equal responsibility on the part of educators to facilitate this style of inquiry learning, focusing upon problem-solving case studies rather than testing its detailed components (Stewart, 1990; Lee, 1994). To do
so will entail vigilant studies to investigate the properties of these phenomena.

For the teaching and learning of anatomy, Richards, Sawyer, and Roark, (1987) created 3-D images of anatomical structures to teach gross anatomy and reported positive reactions and responses from 91 volunteer first-year medical students. Initially, the whole group completed a survey about their attitudes towards the use of 3-D images in their anatomy course. The cohort was randomly divided into three groups of 36, 29 and 26 students respectively. To complete the study, the authors constructed a wire-frame to represent the abdominal and thoracic cavities in 3-D. Whilst running, the videotape included a brief narration which described the structures being shown, their plane and perspective of rotation. These images were shown in a variation of colour via computerized vector graphics. For the experiment, the wire-frame construction was videotaped whilst rotating. The first group was shown the videotape before beginning a three-week gross dissection laboratory, the second group was shown the same videotape after the three-week gross dissection laboratory, and the third group completed an overall survey by questionnaire but did not see the videotape. The questionnaire surveyed student attitudes about the use of 3-D images, measured a self-assessment of their own mental images, and evaluated reactions to the images on the videotape. In summary, 86% of the total group of 91 students believed that seeing the 3-D images of anatomical structures assisted them to visualise those structures; seventy-one percent of the 65 students who witnessed the videotape recommended that 3-D imagery be utilised throughout the medical curriculum. Regrettably, whilst these authors reported details of student feedback, declaring that the group who saw the videotape after the gross
dissection experience tended to visualise clearer images, they did not identify the discrete responses of the group who did not witness the videotape.

Furthermore, Jones, Olafson, and Sutin (1978) used computers to compare the results of freshmen medical students with those in traditional classes to show that they could learn gross anatomy equally well without lectures or dissection. In a comparative investigation of a volunteer group of 48 medical students sequestered from a total class of 151, Walsh and Bohn (1990) used CAL packages to teach human gross anatomy and could find no significant difference between the two groups, with the computer group maintaining a positive attitude throughout. These authors were affirmed by comparative studies undertaken by Lanza and Roselli (1991); Lee and Allison (1992 & 1993); Lee and Kemp (1994); and Lee (1994) in the assertion thatICALP modules can be as effective as lectures for the presentation of anatomy to physiotherapy students.

To meet the continuing needs of health educators for learning in medical sciences, VanBiervliet and Gest (1994) reported significant improvements in the design and delivery of The Anatomy Project, a joint British and American effort. The current set of seven videodiscs and programs will be expanded to 26 volumes of interactive courseware incorporating sophisticated design and CD-ROM related to clinical human anatomy. The advent of these superior software resources in anatomy ensures the potential for expansion of this subject for presentation to autonomous self-paced learners.
2.24 Physiotherapy and its student population

In a paper which discussed the reasons why many physiotherapy students at the entry-level may not be prepared for the professional needs of the 1990's, Shepard and Jensen (1990) presented a curriculum framework to develop a new kind of physiotherapy practitioner, identified as a 'reflective practitioner'. The background to the problems presented by Shepard and Jensen included: advances in medical technology; increasing needs to control health care costs; an aging population with chronic rather than acute illnesses; in an environment which contains increasingly complex sociocultural problems. These authors recommended Eisner's (1985) model of explicit, implicit and null curricula. Examples of explicit curricula include prerequisite course work, as well as academic and clinical education. The components of implicit course curricula are those presented by example from already qualified staff and faculty. Examples of implicit curriculum components are, 'critical thinking as inherent in health care professional behaviour' dealt with by the 'critical analysis of information, brainstorming of ideas, and tolerance of ambiguity demonstrated in every curricular component; curriculum time scheduled for processing and integrating curriculum materials'. Other examples given for the implicit domain were: 'expectations of lifelong service to the profession' countered by 'faculty members who participate in committees and the task forces of boards, districts, State, and national levels'; or 'reliance on self rather than others in the acquisition of knowledge requiring use of a collection of articles for required reading rather than memorisation of lecture notes'. Eisner's null curriculum refers to what is missing from course curricula, or what is left out. To meet these demands, Shepard and Jensen recommend that faculty members ask themselves questions, such as
'will students be prepared with the skills needed to respond to future population needs in a cost-effective way?', and 'are students taught to work collaboratively with professional colleagues and to effectively delegate to and supervise technical-level colleagues?'. Other questions raised by Shepard and Jensen for the null curricula domain relate to assisting the carers of patients to acquire 'hands on skills' as well as the promotion of autonomous patterns of lifelong learning in order to become a reflective practitioner in tomorrow's world.

According to Griffin (1993), it is important to allow students to make choices and to be actively responsible for the outcomes of their learning. Griffin's approach is verified by Zadnick, Singer, Simpson and Treagust (1990), who reported success in a contextually integrated approach to learning physical principles by physiotherapy students. When taught separately, physical principles are generally not understood by students, whereas, when the principles are integrated with other course materials, a better spirit of cooperation and level of understanding is expressed by physiotherapy students.

In an effort to maintain the momentum of staff and academic faculty responsibilities outlined by Shepard and Jensen (1990) support was given for the development of self-paced and self-directed learning presented by Higgs & Boud (1991), who advocate an environment which stimulates life-long learning. To meet these requirements, Higgs & Boud recommend a concept of learner task maturity with a blending of skills acquired from previous tasks which enable the learner to engage effectively with the task in hand. Unfortunately, such principles are frequently confounded by the conflicting roles of dependency imposed on students by staff using rigorous testing devices whilst simultaneously striving to induce autonomous behaviour (Griffith,

In world structure endowed by rising aspirations, students wishing to gain entrance to physiotherapy programs are no exception. There is a wide range of criteria applied to the selection of suitable applicants to university-based physiotherapy programs. This varies from the need to meet basic academic admission requirements, furthered by strategies to identify a sense of vocation, to an entire selection screened from a set point on a computerized list of applicants according to scores gained from predetermined subjects (Balogun, Karacoloff, & Farina, 1986; Benzies-Levine, Knect, & Eisen, 1986; Gartland, 1977; Hahn, 1984; Kerr, 1985; Lee, 1994; Nayer, 1992; Pickles, 1977; Rikard-Bell, Marshall, & Chekaluk, 1991; Williams, 1984).

Caution about the motives and value of testing is raised by Bond (1992) and Tannock (1995), who argue that mass testing of students for university entrance merely measures their competency whilst undergoing the tests. Bond claims that tests in a written format resemble measuring bags of sugar with a ruler, which determines nothing about its mass. Instead, although time consuming, Bond and Tannock advocate a move towards problem-based tests in a broad range of subjects to measure optimal human performance to gauge admission to higher centres of learning.

According to Day (1995), Australian universities increased their numbers by 64% in the decade between 1983 and 1993. This expansion is coincidental to variations of aspiration in a volatile socio-economic
climate. As a consequence, these institutions now accept candidates from a wider background, reflected by a variation in cut-off scores gained in the Tertiary Entrance Examination (TEE). For 1995, in Western Australia, the base-line admission requirement for university entrance was a scaled mark of 270 points out of a highest possible score of 510 in the TEE. The cut-off point for entrance to medicine was 447 in 1994, and 442 in 1995. In the same time frame, the minimum requirement for admission to the physiotherapy course was 405, and 395 respectively (Day, 1995). These figures give a clear indication of the competitive nature of admission to the physiotherapy program at Curtin, with a 10:1 ratio of qualified applicants to those accepted for enrolment. From this, it is also clear that admission to the physiotherapy course in Western Australia is one of status rather than a particular sense of vocation. Due to this, enrolled physiotherapy students are ranked next to those accepted for medicine and veterinary science by virtue of their TEE scores. The majority of enrolling students are recent high school graduates, interlaced with a portion of overseas, fee earning, scholarship students, and mature-aged candidates with special qualities (Lee, 1994).

The situation at Curtin generally coincides with that reported from the University of Sydney’s Cumberland College of Health Sciences by Rikard-Bell, Marshall, and Chekaluk (1991). These authors could find no significant difference in the performance of male and female students throughout their course to graduation, nor evidence to support the level of admission required to gain entry to that course, which proved only to be a poor to moderate indicator of later academic performance. To draw these conclusions, statistical evaluations were undertaken by chi-square evaluation, t - tests, and analyses of variance
to the 799 students who commenced the physiotherapy program at Cumberland between 1982 and 1986. Throughout, these students were classified as either direct entry high school graduates (category A) or non-high school graduates, which included mature-age individuals of 23 years or over (category B). During the study period, student selection was based upon previous academic performance for both categories, with assessment by personal interview for category B students only. Overall, there was no significant differences in the time taken to complete the undergraduate program by both groups. The category B group performed better in the first year, which was not surprising in a highly competitive program at an inherent high level of motivation exhibited by mature-age students. These observations coincide with those of Rogers (1969), Romiszowski (1992), Walker (1975), and Young (1990). Furthermore, at Cumberland, in 26 out of 31 compulsory subjects there were no observable differences in the results gained by either group, with the B category performing significantly better in two academic and one clinical subject. In only one subject, biological science, did the mature-age group perform less well. From these data, the authors could find no significant predictors to determine later performance by either male or female students, or indicators to justify the level of achievement required to gain admission to the program in the first instance, gives anything more than a poor to moderate indication of future academic performance.

These findings raise serious questions about the tendency of academic selectors to rely only upon a high level of achievement for tertiary admission into professional courses (Bond, 1992; Lee, 1994; Tannock, 1995).
2.25 Anatomy and the practice of physiotherapy

Since its inception, anatomical information has been presented to physiotherapy students by lectures, demonstrations, and problem-based laboratory sessions, reinforced by prospected cadavers, and other visual aids. These methods have been supplemented by commercially produced packages, such as the Anatomy Project (Abrahams, 1990; VanBiervliet & Gest, 1994) the Versalius Project (McCracken & Spurgeon, 1991) the Electric Cadaver (Freedman & Chase, 1990) ADAM, an acronym for Animated Dissection of Anatomy for Medicine, and Eve, all of which provide a database of multimedia courseware developed to access study materials of human anatomy and medical terminology (Swayne, 1992). From this, it is clear that healthcare students can use interactive multimedia techniques for safe exploration of environments which would otherwise be expensive and dangerous to human life (Boyle & Doyle, 1992).

Although Lee and Allison (1992) established parochial ICALP materials to be effective when teaching 2-D anatomy to physiotherapy students, in general terms, minimal research has been carried out to investigate the ideal relationship of ICAL modalities with other educational techniques (Jones, et al., 1978; Richards, et al., 1987; Walsh & Bohn, 1990), and there is a need to review the appropriation of resources to research their influence on undergraduate students.

In general terms, prior to 1991, minimal research has been carried out to investigate the ideal relationship of ICALP modalities with other educational techniques (Jones, et al., 1978; Lee, 1994; Richards, et al., 1987; Walsh and Bohn, 1990), with a need to review the appropriation of resources to research their influence on undergraduate students.
Nevertheless, the efficacy of computer-assisted instruction has been well substantiated in medical education (Ashwood, et al., 1986; Branch, et al., 1987; Florey, 1988; Harkin, et al., 1986; Hmelo, 1989; Levine, et al., 1987). Its value has been verified by meta-analysis (Kulik, et al., 1986; McKenna, 1993) and the mean differences of group design, defended by Nelson in 1988. Evidence from the literature suggests that CAL should be highly visual, to involve the student at a cognitive level as well as provide operative, rather than figurative knowledge (Arons, 1984; Meals & Kabo, 1980; Rochford, 1985).

Because the study of anatomy is a visual and descriptive science, observations of its new students suggest that some experience difficulties with the cognitive integration of visual, verbal and written constructs into a third dimension (Meals & Kabo, 1980; Rochford, 1985). To determine the relationship of under achievement in anatomy and spatial relationships Rochford (1985) investigated two populations of second-year medical students. The first population (Population I) consisted of thirty-eight students who were failing in anatomy by mid-year of the first year of their course. The second population (Population II) consisted of 154 novice students in anatomy who were tested by a battery of three-dimensional geometrical spatial exercises at the commencement of the subsequent academic year. These exercises involved the sectioning, joining, translation, rotation and visualisation of simple field objects. Spatial and non-spatial anatomical tests were identified and recorded separately. Spatial anatomical achievement was tested by the use of cadavers, models and a range of multiple choice question tests classified as spatially three-dimensional by a panel of lecturers. Whereas non-spatial anatomical achievement was measured by results obtained in essay and multiple choice question test scores in
the subject. Spatial and non-spatial testing of both populations identified that the statistically significant findings recorded in Population I were also identifiable in Population II, from which it became possible to predict those most likely to fail in anatomy in subsequent years. From this it was found that a persistent deficit in geometric and spatial multiple choice question test scores with a number of quality errors in sketches, is a particularly good diagnostic indicator of serious anatomical weaknesses.

On face value, from Rochford's (1985) data, it would appear that those with well developed written and verbal skills are more likely to overcome this difficulty sooner. However, Lee and Allison (1992 & 1993) and Lee (1994) assert a need for longitudinal studies to investigate this phenomena, in order to identify a predictive model which facilitates the transition of previously learned 2-D information into a 3-D, practical skill. From this knowledge base, these authors were encouraged to research the development and impact of parochial, interactive computer-assisted learning packages for the teaching and learning of anatomy to undergraduate and postgraduate physiotherapy students.

2.26 A computer managed environment for learning anatomy

Any form of unsupervised learning may be equated with Distance Education. In general terms, distance learning refers to the acquisition of knowledge from materials designed to facilitate individualised learning at the site of delivery (Condon, 1992).

interactive multimedia to undergraduate physiotherapy students. These programs were focused upon the presentation of video tape and videodisc images via Asymetrix Toolbook, with plans to develop digitised data and 'in-house' CD-ROM. Although the use of videotape was abandoned because of its slow response to interactive use, the author reported positive student responses to this form of learning, substantiated by pre and posttest results achieved by interactive study (Christie, 1988, 1992). After an admirable review of contemporary hardware and software, with the likely emergence of less expensive new interactive technology, the author concluded: 'As always, the stumbling block will be how effectively we, as educators, are able to use this technology to solve educational problems'.

Computer-assisted learning can provide individualised self-paced learning in a non-threatening environment whilst allowing its learners to evaluate their own rate of progress when mastering the basic information. Such autonomous students of anatomy, who are self-paced, may be facilitated to learn in the same way in a computer-managed learning environment (Lee, 1994). In an effort to assess the value of computer lessons in eight selected topics of gross anatomy, Walsh & Bohn (1990) provided programs for a volunteer group of 48 first-year medical students out of a class of 151 students. At the end of the gross anatomy course, all participants were evaluated by an objective multiple choice question regime, accompanied by an anonymous questionnaire which ranked the value of the learning programs on a scale from 1.0 to 10.0, with 1.0 representing 'extremely helpful' and 10.0 'being of no value'. Although a comparison of the test scores showed no significant difference in the test performance of the computer-assisted group and non-users, the responses of the computer
group revealed a very positive attitude, with an overall rating of the computer programs at 1.8. From these results, the authors concluded computer-assisted instruction to be of educational value when mastering the subject of human gross anatomy. The findings of Walsh and Bohn (1990) coincide with those of Lanza and Roselli (1991) and Lee (1994), none of whom claim significant differences between groups of learners but can affirm educational gains by interaction with the subject and instant feedback of test results.

In a description of experiences in the development of courseware in some aspects of pre-clinical anatomy, Tan, Rajendran, and Voon (1990) illustrate how computer images can be made to 'dissect' the human body. These efforts were further reinforced by Rajendran, et al., (1990) in a discussion of the power of computers to enable medical and dental students to learn gross human anatomy more effectively. In the same way, Cross and Laidler (1990), described the objectives, design and performance of a computer-assisted program of textual simulation at autopsies. These authors also demonstrated CAL to be useful for a correct introduction of medical students to the procedures of death certification, a much neglected area of medical education.

To comprehend the spatial relationships of neurological structure and function, Dori, Dori, and Yochim (1994) effectively used multimedia technology to enhance Intelligent Computer-Aided Instruction (ICAI). Techniques were illustrated to enable students to look inside the brain, viewing specific parts to link structure with function. A pathmap of navigation was also shown to foster mastery learning with a final screen to grade each level of success. When students are empowered by the freedom to learn, they will invariably get stuck (Feifer & Holyoak,
1994). If a resource person is available, such students can be supported by a procedural nudge. Such a nudge can be given to independent learners in a computer-managed learning environment (Lee, 1994) by the incorporation of personality traits which may be attributed to a resource person. In response to this problem, Feifer & Holyoak (1994) observed five human personality types which may be emulated to provide procedural nudges in a computer-based learning environment. Four out of five of the personality types would be useful to get a student unstuck, but the fifth, classified as the 'Eager Expert' (EE), would not. EE understands the domain, knows about student problems, is smart, but doesn't have the time or patience to facilitate a level of understanding by the student working through the problem. EE simply gives the answer. This portrait of EE typifies the kind of help available in traditional classes and educational software, but rarely results in learning. In essence, these models demonstrate a need for a synergy of modern educational theory with multimedia technology (Voon, 1992).

During the elucidation of a computer-managed learning environment (CMLE) for students of anatomy, Lee & Kemp (1994) demonstrate it to be most effective when its learners are empowered to access materials to meet their own needs (Lee & Allison, 1992 & 1993; Lee & Cameron, 1994). Rates of progress can be accelerated by the facility for learners to monitor their own level of competence by instant feedback (Lee, 1994). During an investigation of strategies to provide pathways for learners in a CMLE, funded by a grant from the Committee for the Advancement of University Teaching (CAUT) awarded to Lee, Cameron, Phillips & Borzyskowski (1993), Lee developed a Self Operated Computer Controlled Educational Resource (SOCCER), which not only proved to be an effective navigational
instrument for the deployment of ICALP materials but also empowered students to assess their own performance whilst learning anatomy (Lee, 1994). Note was taken of the principles advocated by Alessi and Trollip (1991) when developing ICALP modules in SOCCER. These principles included: the content and presentation of information; guidance to simulate lecturer-learner interaction; an environment of unrestricted practice for the learner; and continuous mutual assessment of student learning. To meet these principles, SOCCER was developed to enable each learner to register by a unique password with unlimited access to learning and testing materials. In this way, all individual learner activities can be continuously tracked and recorded for reciprocal evaluation between staff and students throughout any designated period. The resultant data provides information about learning from pretests and the acquisition of new information during progression to posttests under controlled conditions for continuous review by learners and administrators alike. SOCCER provides an unlimited interactive access to ICALP modules, Multiple Choice Question Test Items (MCQTI), and True-False Test Items (TFTI) in a sensitive learning environment with a Feed-Back Instrument (FBI) to evaluate learner reactions to the CMLE.

2.27 ICALP and anatomy for physiotherapy students
Applied, functional and clinical anatomy is fundamental to the practice of physiotherapy invariably presented by lectures, demonstrations, laboratory sessions, prosected cadavers, mounted specimens, models, and other materials. As previously mentioned, observation of naive students of anatomy suggests that some experience difficulty with the transmission of visual, verbal and written constructs into a third dimension (Arons, 1984; Meals & Kabo, 1980; Rochford, 1985).
Although it appears that those with well developed written and verbal skills are more likely to overcome this difficulty sooner, there remains a need to correlate studies to investigate the value of ICALP when learning of 2-D information and its transposition into a 3-D ability (Lee, 1994; Lee & Allison, 1992 & 1993). These authors clarified the need to investigate the proportional relationship of ICALP modules with other educational techniques, reinforcing the views of Jones, et al., 1978; Richards, et al., 1987; and Walsh and Bohn, 1990.

2.28 ICALP compared with Lectures and the retention of knowledge

Following the successful comparison of the retention of knowledge by multimedia to paramedics following a period of continued education by Porter in 1991, Lee and Allison (1993) advanced these findings to demonstrate the retention of neuroanatomical information gained by ICALP. In this latter study, identical information was given to 41 students in lectures and to 37 students by ICALP. A standard pre-post-retest regime was administered. The pretest was followed by an intensive five week learning period, where the ICALP and lecture groups studied identical materials in exclusive environments. The same test was applied to both groups at the end of the five week learning period and then, unexpectedly, re-applied to the same groups at 60 and 120 day intervals thereafter. The overall results of the lecture group showed a mean of 43.58 with a standard deviation of 8.67 at pretest, a mean value of 73.19 and a standard deviation of 7.76 at posttest, a mean of 68.04 with a standard deviation 8.49 when re-tested after 60 Days, and a mean of 68.06 with a standard deviation of 8.24 after 120 Days. The results for the same tests by the ICALP group are as follows: a mean of 44.81 with a standard deviation of 6.54 at pretest; a mean of 75.42 and a standard deviation of 6.76 at posttest; a mean of
70.34 and a standard deviation of 9.58 at the 60 Day re-test; and a mean of 69.68 and a standard deviation of 9.02 at the 120 Day re-test. Scrutiny of the data from the three paradigms showed no statistically significant differences between the two groups.

2.29 The GEFT

An investigation of the Embedded Figures Test (EFT) suggest it may be an effective instrument to recognise the perceptual qualities and learning styles of the members of any group (Witkin, Oltman, Raskin and Karp, 1971; Burger, 1985; Rochford, 1985). Although the EFT may quickly identify subjects who can ‘dis-embed’ a geometric figure from an obscure background in a limited amount of time, the Group Embedded Figures Test (GEFT) may prove to be an effective alternative when testing individuals in large groups (Witkin, et al., 1971; Rochford, 1985). Studies of medical students indicate the possession of high spatial abilities when measured by Witkin's Embedded Figures Test (Witkin, Moore, Oltman, Goodenough, Friedman, Owen, & Raskin, 1977). However, this level of success is not reflected by all students throughout their medical career (Rochford, 1985). Rochford's findings over a 4-year investigation of spatial learning difficulties and under achievement among medical anatomy students, established that one third of the annual intake of anatomy students at the University of Cape Town began the course with a measurable spatial deficit. From this research, Rochford verified this handicap to occur among high, medium and low achievers in anatomy, where although most students acquire satisfactory anatomical spatial skills over a period of 2-8 months, 7-10% of students are unable to do so. Of more concern is the comment by Rochford that ‘students of above-average all-round ability usually pass anatomy by gaining high
marks on non-spatial questions in anatomy, thus off-setting their hitherto undetected spatial weakness’. To identify anatomy students with a spatial deficit and reduce the risk of repeated failure, Rochford advocated a regime of spatial testing and rehabilitation, citing the work of Blade and Watson (1955) and Eliot (1980) for this purpose.

When postgraduate medical specialists were tested by Goodenough (1977), significant rank-order differences were found between radiologists, surgeons, internists and psychiatrists. As might be expected, surgeons and radiologists proved to be the most field dependent, with significant differences between psychiatrists and surgeons. From this information, Goodenough suggested that: 'long range predictions about medical career development can be made with some degree of accuracy from knowledge of an individual's cognitive style'.

2.30 GEFT to predicate the transfer 2-D information into a 3-D skill

As outlined in section 2.29 of this thesis, a number of new students in anatomy experience difficulty with the cognitive integration of visual, verbal and written constructs and the transfer if this information into a third dimension (Meals & Kabo, 1980; Rochford, 1985). The relationship between field-dependent and field-independent attributes and the correlation of the GEFT with the acquisition of 2-D knowledge and its transposition into a 3-D skill, has not yet been reported (Lee & Allison, 1993). Although those with well developed written and verbal skills are more likely to overcome this difficulty sooner, there remains a need for longitudinal studies to investigate the value of ICALP in the learning of 2-D information and its transposition into a three-dimensional (3-D) domain.
From this preliminary review, GEFT may prove to be an efficient instrument from which to predicate those most suited to computer-assisted learning, as well as to identify those with 2-D perceptual difficulties who may need special treatment to compensate for a defective 3-D ability (Witkin, et al., 1971; Kenner, 1984; Mohr, 1987). However, Burger (1985) used the GEFT to investigate the relationship between learning style, preference for computer-assisted instruction and the academic achievement of a non-random sample of 81 undergraduates in a population of n=291 enrolled in a medical terminology course undertaken by CAI. To measure learning style, each student was given a score ranging from 2, indicating field dependence, to 18, indicating field independence, with a Spearman's rho to determine relationships among three variables, which were as follows. Firstly, the correlation between a preference for CAI and learning style \( r (79) = -0.11, p = 0.328 \) was found not to be significant. Secondly, the correlation of a preference for CAI with academic achievement \( r (79) = 0.22, p = 0.048 \) was considered to be small but statistically significant. Finally, the correlation of learning style with academic achievement \( r (79) = 0.18, p = 0.108 \) was considered to be of no significance. Hence, a small but statistically significant correlation between CAI preference and academic achievement was identified with no determinable difference between learning style and academic achievement. From these data Burger concluded that students with higher grades appeared to favour CAI, but could find no clear relationship with either a preference for CAI or their academic achievement.

Similar findings to those of Burger (1985) were identified by Lee and Allison (1993) during a comparative study of ICALP materials with
traditional lectures in anatomy. Although GEFT scores were elicited as a tool to predicate computer-assisted learners, when applied, results ranked 95% of the student body as field independent with scores above 16. From these data, Lee and Allison determined GEFT scores to be insufficiently sensitive to identify a range of learning styles among a body of high achievers.

2.31 Quality Assurance
The rapid advancements made in information technology have changed the way material is stored for access and presentation to tertiary students (Hobbs, 1993; Stringer, 1992 & 1993). As these developments are advanced by software compression and other techniques, so does the need for CMLE's to accommodate access to interactive computer-assisted learning packages, networks and library-based CD-ROM databases to facilitate self-directed learning and navigation (Lee, 1994; Lee & Cameron, 1994; Lee & Kemp, 1994). To overcome some of these problems, techniques were developed to establish quality assurance and cost-effectiveness at Curtin (Canale & Wills, 1993; Cameron & Barratt, 1992; Edwards & Fox, 1993; Glaister, 1994; Lee, 1994; Lee & Cameron, 1994).

2.32 Self-paced and self-directed learning
Since the warnings issued about the complexities facing low-ability students in an open learning system (Artus & Keenan, 1994; Atkinson, 1968; Balajthy, 1988; Breugel, 1991; Chen, 1989; Glaser, 1968; Goldschmid & Goldschmid, 1974; Higgs & Boud, 1991; Ross, et al., 1988; Shepard & Jensen 1990; Suppes, 1966; Yochim & Dori, 1993), the use of multimedia in education has de-emphasised the delivery of information by traditional teachers to one which facilitates the
processes of learning. With these changes, the teacher-lecturer becomes a true facilitator and manager of the learning process with guidance to sources of knowledge (Jonassen, 1991; Khoo, 1994). Inevitably, such openness presents the learner with the complexities of system navigation. One of the main problems associated with navigation through computerized learning systems is disorientation (Andrews, Kappe & Schipflinger, 1994; Cameron, 1993; Lee & Cameron, 1994).

In an introduction to SOCCER and self-directed learning, Lee & Kemp (1994) demonstrate its success for the independent navigation of self-paced and self-directed learners in a challenging environment. In an elucidation of SOCCER, its ability to continuously monitor rates of progress with continuous feed-back in a CMLE was described. This paper reviewed and discussed differing computer-assisted learning styles at the tertiary level (Jones, et al., 1978; Lee, 1994; Lee & Allison, 1992 & 1993; Lee & Cameron, 1994; Lee & Kemp, 1994; McCracken & Spurgeon, 1991; Starkweather, 1986; Walsh & Bohn, 1990).

The development and implementation of SOCCER in a CMLE was shown to be a facility to obtain data for educational research and administrative cost-effectiveness. SOCCER was also shown to provide freedom of access to learning materials as well as to record and track the activities of Physiotherapy students whilst learning anatomy. These techniques were shown, not only to empower anatomy students to become self-paced and self-directed learners, but also to measure and respond to feedback techniques which enable academic staff to place the responsibility for the acquisition of knowledge directly upon the learner. This method was shown to create a climate for problem-based
learning and thinking at a more advanced dimension than could otherwise be expected.

2.33 Problem-based learning

As already mentioned, problem-based learning (Mitrani & Swan 1990; Newble & Cannon, 1991; Thompson & Williams, 1985), which may be attributed to the dialectic of Socrates and inductive reasoning of Plato, in combination with the Aristotelian logic of the Classical Period observed more than 2,500 years ago, was later verified by the investigation of volitional behaviour in chimpanzees by Kohler (1925).

Menkel-Meadow (1992) noted that recognition of cooperative student effort leads to an improvement in the quality of their learning. It has also been observed that students construct knowledge more effectively by participating with others during the learning process (Sigel & Cocking, 1977). Stevens (1989) effectively compared computer-based problem-solving examinations with objective essay examinations to predict the performance of second-year medical students in immunology. Using this premise, the results obtained by Lee & Kemp (1994) not only validate the effectiveness of SOCCER as a navigational instrument, but also that ICALP and test items can be presented in a CMLE to reinforce formal lectures given on any topic. On average, the time spent by individuals in SOCCER was shown to be equivalent to that normally spent in a library or home based study. As a result, lectures in the fourth semester were converted to seminar-discussion sessions in a climate of problem-based learning, advancing the rate of progress beyond that which could otherwise be expected (Barrows, 1983, 1986, 1988; Barrows & Tamblyn, 1980; Birch, 1986; Boud & Felletti, 1991; Khoo & Kingsland, 1994; Lee, 1994; Newble & Cannon,
(1991; Reeves, 1992b; Stevens, 1989; Thompson and Williams 1985; Wallis, 1988).

2.34 Identification of a tolerance of modalities
Evidence from the literature suggests that CBL should be highly visual, involve the student at a cognitive level and provide operative, rather than figurative knowledge (Arons, 1984; Meals and Kabo, 1980; Rochford, 1985). Ashwood, et al., (1986) emphasised the importance of visual information in CAI, enhanced by good graphics and video images, declaring this combined modality to have great potential in all areas of medical education.

Although Lee and Allison (1992) established ICALP to be effective in the teaching of 2-D anatomy to physiotherapy students, the need for appropriate research in a CMLE became evident in order to find an ideal proportional relationship of ICALP modalities alongside traditional educational techniques (Jones, et al., 1978; Richards, et al., 1987; Walsh & Bohn, 1990). To avoid anxiety in an environment containing a continuum of information overload, learning how to identify, select and evaluate data from a wealth of resources becomes an additional educational responsibility. This aspect was emphasised by Imel (1990), who described the anxiety of individuals when surrounded by vast amounts of knowledge and data, perhaps feeling overwhelmed by its volume, or unaware of its existence and how to look for it. These comments are reinforced by Miller (1992), who identified members of the information industry as verbally-oriented and accustomed to downloading hundreds of pages of text in order to glean a few facts. In addition, Miller believes that humans have almost reached the limit of
the amount of information they can absorb unless significant changes are made in the way they think.

Lee and Allison (1992) urged software developers to continue to investigate all aspects of the development of interactive learning programs to identify an educational level of tolerance to find a proper balance between CBL and other methods of instruction in a tertiary environment. These comments are compatible with those of Cesnik and Kidd (1989); Imel (1990); Spencer, (1990); Andrews, Schwarz and Helme, (1992); Hutchings, Thorogood and Hall, (1992); Kidd, Cesnik, Connolly and Carson, (1992); Kidd, et al., (1992); Lee and Allison, (1992); Miller, (1992); and Lee, (1994).

2.35 SOCCER and ScoLar in a CMLE

In an introduction to SOCCER and self-directed learning, Lee and Kemp (1994) affirm it can be most effective when designed to provide pathways and freedom of choice which empower learners to access materials which meet their own needs (Lee, 1994); Lee & Allison, 1992 & 1993). In this way, individual rates of progress can be accelerated and reinforced by instant feedback prior to tests under controlled conditions.

SOCCER was developed to facilitate the teaching and learning of anatomy by physiotherapy students in a CMLE to provide data to measure and validate the performance of learners and educators in discrete areas of anatomy. In 1993, plans were in hand to convert SOCCER from a HyperCard driven black and white format to colour, afforded by a combination of QuickTime and SuperCard (Borzyskowski & Pearson, 1994). Several pilot colour ICALP projects
were developed for conversion to what was to be known as ScoLar (Student Operated Learning and Assessment Resource; Lee, 1994). It was intended to extend the present study by comparison of the effects of learning by SOCCER in B&W with identical colour ICALP materials accessed via ScoLar. Unfortunately, because of budget constraints to arrange a separate colour mounted CMLE, or up-grade the existing CMLE, the project was set aside until late in 1995.

2.36 The psycho-social environment
Experiential research into human endeavour takes place in an atmosphere of mutual respect and inquiry between researcher, co-researchers, and subjects. According to Heron (1981), these procedures may be classified in three stages, namely: propositional; practical; and experiential. Propositional knowledge is a language dependent paradigm to determine the facts and truths of a stated hypothesis. Practical knowledge is exemplified by observation of individual methods used in the exercise of a special skill, or proficiency. Experiential knowledge investigates the empirical bedrock of the interactive processes which relate individuals in the real world. Heron refers to this as phenomenological mapping, an application of these paradigms to categorise what is going on for the persons on both sides of a human research experience.

Acquired research data from these paradigms infer a need to objectify responses from various sources of feedback. This may be undertaken by use of pre and post tests, subjective and objective evaluation, reviewed by interviews and feedback gained from regular, or intermittent, questionnaires. Naturally, in educational research, the timing of implementation of such devices in an evolving process is of
the essence (Lee, 1994; Knowles, 1984; Smith, 1991). Apart from data collected from formal examinations, Knowles advocates the value of direct and projective questionnaires. Direct questionnaires are simple statements which indicate the personal preferences of respondents. Projective questionnaires use a more subtle approach, which causes the respondent to be projected into the situation under discussion. Hence, direct questions may elicit a, yes; no; or indifferent response, whereas subtle projective questions may be applied to elicit evaluative responses, graded from low to high on a five point scale (Ramsden, 1988). Personal interviews and questionnaires have several limitations. If used frequently they may interfere with the process and arouse resentment from its participants. According to Knowles (1984), although data obtained from anonymous questionnaires is likely to be more reliable, its content cannot be cross-checked against the characteristics of individual participants. In addition, open-ended questions may be used to elicit unexpected information about affect; feelings and attitudes perceived by respondents (Boud & Felliti, 1991; Glaister, 1994; Khoo & Kingsland, 1994; Lee, 1994).

Perceived student anxieties created by threatening situations increase the incidence of surface learning by rote to satisfy the expectations of examiners (Entwistle & Percy, 1974; Hopson & Scally, 1980; Knowles, 1984; Maslow, 1954; Ramsden, 1992; Smith, 1991). The disadvantage of learning information this way, is that it is likely to be discarded almost immediately after the examination (Newble & Cannon, 1991). Therefore, it is not only desirable to introduce a deep approach to cognitive and problem-based learning, but also to involve the learner in the process by obtaining feedback about the procedures taking place.
(Barrows & Tamblyn, 1980; Boud & Felliti, 1991; Gleadow et al., 1993; Hart, 1988; Koppi, 1994; Shapiro, 1988).

One of the greatest disadvantages of written tests and evaluations, is the length of time it takes for the student to gain positive reinforcement and feedback from their results (Fletcher & Collins, 1987). Another problem which may need to be overcome with experimental research in pursuit of hard data during computer-based learning, is the Hawthorne effect created by the psychological stimulation of an innovative environment (Glick & Margolis, 1962; McKenna, 1993; Roethlisberger & Dickson, 1939).

These problems may be overcome by application of well designed CBL systems (Ring, 1994) and feedback instruments (Lee, 1994). According to Pond, Bradshaw, and Turner (1991), learners need to critically assess information gained in the classroom before it can be used in the real world. To deal with more than 800 students of varying background in a university physics course, placing heavy demands on diminishing resources, Loss, et al., (1993) successfully developed a computer based learning program to meet this demand. For these authors, 50% of the initial group of students were either female or from non-English speaking backgrounds. Therefore, a conscious effort was made to present a contextually based format in a gender-neutral learning environment.

These experiences are evident in other programs developed to reach increasing numbers of students with a variation of background and gender balance (Cameron, 1993; Edwards & Fox, 1993; Fox & Edwards, 1990; Fyfe & Fyfe, 1993; Glaister, 1994; O'Connell &
Herrman, 1994; Sampson & Courtney, 1994; Slack-Smith, 1994). From these examples, educators who implement computer-driven learning systems need to be informed about the interactivity and quality of learning by gaining participant feedback on a regular basis (Khoo & Kingsland, 1994; Lee, 1994).

Using a 2,000 word script to describe the function of the human heart, Richards (1989) explored the value of computer-generated feedback. In this experiment, 126 freshmen and sophomore university students were recruited as volunteers from a wide variety of academic subjects. With no apparent gender identification, the cohort was subdivided into three groups of 42 students. The instruction material was delivered by text and graphics in 38 self-paced computer driven instruction packages linked by 'yes-no' responses to measure student reaction to the process. Content of the topic was presented in three major elements designed to gain simple, covert, or overt feedback. No pretests were given, but four posttests were administered to assess drawing ability, identification, terminology, and comprehension. Results from the posttests demonstrated that the various types of feedback techniques used produced different effects upon objective measurements, particularly in the drawing test which required participants to construct and reproduce items in an appropriate context. Furthermore, results showed that non-drill lessons do not automatically ensure an increased learning of content, and that all methods of computer-generated feedback are not equally effective. Richards strongly recommended a need for further research into new methods of computer-generated feedback. From these results and the closing comments made by the author, the matter of greatest significance was related to questions about the accuracy of feedback. It seems that 'overt' responses to 'yes-
'yes-no' style questions do not automatically guarantee an increased state of learning in computerized drill sequences. Nevertheless, Richards indicated that properly designed computer-generated feedback techniques possess the potential to become an effective instrument for such measurement. Unfortunately, in this case counter arguments may be applied. In the main, there was no long-term commitment to the subject matter by a non-specific range of students who were placed in a situation where no pretest was applied, bereft of a prolonged posttest regime to measure the amount of recall. Richards' paper was further confounded by discussion about the true meaning of feedback and clouded by issues concerning responses to the 'yes-no' questions, which appeared to be too objective to evaluate knowledge, or satisfactorily measure reactions to the style of construction and presentation of information.

There are four main reasons to evaluate teaching: to improve the course content and teacher performance; to improve administration in regard to retention, promotion, tenure, funding and salary adjustments; to assist students in their selection of courses; and to substantiate criteria for educational research (Doyle, 1983).

Empirical evidence supports the predictions of Bork (1984) and Gates interviewed by Appleyard (1994) who assert exponential growth of computers in education. Therefore, with an ever increasing diversity of software for differing subjects, it is also important to continually assess student attitudes and responses towards CAI in specific areas (Bangert-Drowns, 1985 & 1993; Kulik & Kulik, 1987). As the implementation of educational technology advances, traditional methods of assessment by written tests and reports more frequently become unsatisfactory
(Stephen, 1994; Tannock, 1995). This need is emphasised by conflicting and inconclusive findings about CAI in education in a review by Niemiec and Walberg (1987).

When designing instruments to gain feedback from groups, every effort must be made to minimise distortion of communication between individual intent and conclusions drawn by those making the measurements (Leavitt & Mueller, 1951). In essence, feedback may be defined as obtaining information from an individual or group about the affect of their behaviour upon others (Joyce & Weil, 1972). To avoid any affront to human dignity, subjects must be informed of the purposes of any research design with an assurance that confidential information will not be misused. Furthermore, the willingness of a participant can be assumed by the return of a questionnaire (Herrington, Fox, Gillard, & Rainford, 1992). Educationally, feedback may be obtained in an open forum as a group process. To control distortion in the presentation of results, it is preferable to appoint a member who is an observer and not a participant (Napier & Gershenfeld, 1973).

When discussing a developmental model of education, Eldred (1994) recognised the need to respond to learner reactions identified by Rowntree (1987). As a follow-up to the presentation of science lectures by computer, Conway (1994) presented an analysis of student reactions to measure the overall benefit of a computer-mediated presentation (CMP). To verify the lecturers opinion that CMP had been better received than traditional lecturing techniques, a computerized questionnaire was developed and applied to quantitatively assess student
reaction. These data were positive, with a strong correlation of scholastic ability and student approval of CMP.

During an evaluation of the delivery of traditional, multimedia and computer-based materials to distance education students, Eldred (1994) recognised certain difficulties associated with an effective open learning environment. Namely, for the establishment of sound educational principles, effective student-centred support networks, and a pedagogical (andragogical) analysis of the role and function of multimedia.

In an innovative self-directed study of methods to teach biology using multimedia programs, Gleadow, et al., (1993) developed an interdisciplinary approach to its presentation and evaluation. The interdisciplinary group was a collaborative enterprise between subject specialists and tutors, in consultation with lecturers in psychology, teaching and learning. In a traditional style, the subject matter was presented as a self-contained, second semester course by a combination of lectures supported by a self-study program directed from a workbook. In 1992, the traditional style was augmented by video films, slide-tape shows, and two computer-assisted packages, which were nominated as weekly activities. Tutorials were held on a fortnightly basis, to provide a platform of evaluation of the weekly activities. The timing of these activities for assessment was planned to motivate its participants. This was undertaken by a combination of attendance and presentation of independent work and feedback during the tutorials. Apart from the lectures, workbook, and professional wildlife video films, two interactive computer programs were developed to form the basis of two separate tutorials and their accompanying activities. The
two computer programs were HyperCard driven for presentation in a 30 work station laboratory environment; each designed to last 50 minutes. Each screen contained graphics and text, linked to photographs, audio material, and video movies via external functions. A straightforward interface was constructed to allow freedom of access in a non-linear format, with variation of graphics to make the content interesting. Questions were scattered throughout to encourage observational skills to provoke on-line answers, as well as register feedback. Assessment and evaluation questions required students to demonstrate an understanding of the subject, as well as providing them with access to information from a variety of sources. Results were determined by student responses to short answer questions, and their presentation of notes, essays, reports, and data. Although 85% of the work was assessed in a final written examination, three of the weekly activities were selected to account for the remaining 15%. Questionnaires were applied to determine study habits, goals and expectations at the beginning and end of the course. The second questionnaire was expanded to initiate responses about the clarity and helpfulness of lectures, the workbook, and the two computer programs. A sub-set of 94 students was asked about their level of experience with computers and about its helpfulness and interest. Over 90% of the group reported previous computer experience, none showing any difficulty with the mechanics of the program. Emphasis of the responses was focused on the content rather than the mechanics of its presentation. The majority of students reported enjoying the availability of the computer programs, especially the freedom of access to self-paced learning. Of interest was that over 80% of students opened sections of non-compulsory material, and that the glossary proved to be a considerable asset by providing ways to understanding
without public exposure of any ignorance. A point of some significance, was that 27% of respondents were unaware of the location of the on-line glossary, indicating a need for careful communication.

This aspect is supported by Lynch (1992), who considers the need for communication to be integrated with privacy, in a non-judgemental environment provided by CAL, to be of prime importance to facilitate learning. Furthermore, Gleadow, et al., declared their evaluation of computer based programs to support the views of Danbury, Jones, Kruper, Lichtenstein, Nelson, Schank, Sterner, Weil, and Wimsatt (1990), to be an effective means to simulate actual experiments. One of the early concerns in this study, was that the quality of interaction between students and tutors might be affected by the use of computers. Instead, the tutors observed that the level of interaction with students was different, less structured, and that groups of 20-35 students became more involved in the dynamics of discussion. From this, these investigators perceived that computer based programs to facilitate the development of problem-solving strategies (Lee, 1994; Schoenfeld, 1990; Stewart, 1990).

In an effort to investigate the potential competence of medical students prior to them becoming physicians, Anabar (1991) used interactive computerized tests to accept an unrestricted natural language input. The population selected were second year medical students in a course of clinical biophysics in 1989. It is generally understood that evaluative tests of knowledge by objective multiple choice questions are fraught with difficulty (Anabar, 1986). Nevertheless, Anabar (1991) affirms the need to rely upon objective multiple choice question tests to evaluate knowledge as a necessary alternative to the prohibitive cost of
other methods. Therefore, concerns raised about the appropriate value of multiple choice questions to evaluate the acquisition and retention of knowledge invoked the 1989 study by Anabar, where 'knowledge' was defined as an effective problem-solving ability to demonstrate mastery of information. From this definition, individuals deficient in knowledge were categorised as incompetent. In the 1991 study by Anbar, cost-effective computer software was developed to allow for unrestricted knowledge input and emulation of an oral examination. In this way, it became possible to evaluate responses to objective multiple choice questions and natural language questions at the same time. Thus the interactive computer program consisted of open-ended clusters of 15 to 20 oral simulated questions blended with standardised multiple choice content. Four or five of these clusters were randomly selected by the computer for interactive presentation to each student during a 60-minute test. To allow for an in-depth assessment of knowledge, the recognised answers were immediately followed by contextually appropriate questions. For further screening, the open-ended clusters contained two or three separate multiple choice test questions. In this way, once a selection had been made from six to ten alternative multiple choice questions, the computerized program interjected with a request to justify a particular choice. In an analysis of the unweighted test scores of 125 students, each response was scored as either correct, or incorrect. Two or three sequential and blatantly incorrect responses were classified as 'utter lack of knowledge of the subject matter'. For the entire population (n=125), a weak positive correlation was found between multiple choice and open ended responses (slope = 0.24, r = 0.19, p = 0.034). However, when the population was re-classified into two groups and three scoring parameters, Anbar determined the following results. Among the 54 students with open ended results of
<0.65, a positive and highly significant correlation was found between open ended and multiple choice scores (slope = 1.03, r = 0.45, p = 0.0006). For the 71 students with open ended results of > 0.65, the correlation was considered significantly negative (slope = -0.58, r = 0.32, p = 0.0038). From these data, although the mean scores of correctness for the multiple choice responses were found to be the same in the upper and lower class levels, Anbar asserted a qualitative correlation of the results of both groups were found to be significantly positive for the lower half of the class and negative for the upper, suggesting that the two styles of testing measure different levels of competence. From these results, the author concluded that students who excel in an oral examination environment are likely to perform relatively poorly in a multiple choice examination. Similarly, that successful achievement in a multiple choice test may be a poor indicator of likely performance in an interactive open-ended environment. Further, if the latter is considered to be a more accurate measure of competence, multiple choice questions (alone) seem to fail as a means to provide a correct assessment of this attribute. The author suggests that poor performance in multiple choice tests may be explained by an excessive interpretation of the question by creative, intelligent, and knowledgeable students. Such students are unable to believe that the author of the question requires a trivial answer, instead they choose a more sophisticated response, which could be rationalised orally if given the opportunity. This paper affirms Reeves (1992b) by the need to eschew a reliance upon multiple choice tests alone, putting a strong case for an admixture of objective and open-ended questions situationally blended to represent an oral examination, driven by a computer.
To remove the tedium from quantitative analysis of data, Harris & Maurer (1994) successfully integrated the use of HyperCard software when obtaining user feedback in an investigation of high level event monitoring. In an elaboration of the 'button theory' espoused by Jona, Bell & Birnbaum (1991), Looi, Chay, Chew & Chan (1994) used HyperCard stacks to allow students to express their feelings about interactive questions at the touch of a button on the keyboard. These findings are verified by those of Lee and Allison (1993) and Lee (1994).

Recker (1994) demonstrated the value of hypertext in an analysis of methodologies used to identify patterns of learner cognition during interactive navigation. These studies are enhanced by the findings of Ring (1994) in a pilot project which was not only able to objectively test student results in a non-threatening environment, but also gain information from learner feedback.

As already described, Pollard and Davenport (1994) reported positive responses in an evaluation of CAL modules to United Kingdom dental practitioners. Although the conduct of intensive case studies (Stake, 1978) and the application of prescriptive theory (Clark, 1989) advocated by Reeves (1992a) were beyond the capabilities of this project, the advantages provided by a computerized feedback instrument are that it can be undertaken by individuals in isolation to record and measure information without contamination of the results by collusion with other members of a research group (Lee, 1994).
2.37 The relative cost-effectiveness of CBL with traditional methods

It was not until the early 1960's that the subject of economics in education was seriously introduced (Blaug, 1968). This is not to say that the economics of education were considered of no consequence previously, simply that discrete studies of the processes of education were rarely connected to the growth of human investment (Schultz, 1961). According to Schultz, whilst it is obvious that individuals acquire useful skills and knowledge whilst learning, it is not obvious that these skills are visualised as a human growth resource. At the same time, Kershaw (1965) addressed the problem of increasing educational costs and optimum class sizes in secondary and tertiary education. Kershaw was obviously aware of the impending revolution of technology in education and how it may affect the benefit of the current student-teacher ratio. In answer to this problem, Kershaw advocated an increased through-put of students per faculty member. To meet these changes, Johnson (1964) invoked a need for policy-makers to relate education to the economics of its outcomes. In review, these developments may be exemplified by studies of educational consumption, or earnings foregone by mature-age students attending university, in a wide range of reports from Becker in 1964 and Kershaw in 1964, to Khoo and Kingsland in 1994. In this period, the economics of education in particular, and the capital growth of human resources in general, have been vigorously revolutionised.

In order to measure items associated with the presentation of higher education, Adams, Hankins, and Schroeder (1978) defined such analysis as: 'any manipulation of cost data that is done to provide relevant information for those who make decisions'. However, these authors
could find no suitable literature to identify a method which characterised a differential of analytical methods. After further consideration, Adams et al., were able to determine three main principles of cost analysis, namely: Composition Analysis, or the sub-categorisation of an aggregate cost; Relational Analysis, or the determination of the functional relationship between cost and independent variable(s); Direct Comparison of two costs.

In an environment which is distinctly learner orientated, the advantages of Adams et al., may include a reduction in learning time, accompanied by greater retention of knowledge by the learner, in combination with an equivalent cost-reduction in delivery (Khoo, 1994). Although Kingsland (1994), introduced caution when discussing points of conflict between the notions of efficacy and efficiency. He defined educational efficiency as teaching more students in larger classes by fewer staff members enabling more time for research and grant applications, with increased efficacy directed towards the creation and maximisation of learning environments. When faced with this dilemma, advantage must be taken of the minimal response time sequence of interactivity espoused by Ellis (1994) and the growing body of research which supports the advantages of multimedia technologies in comparison with traditional forms of teaching (Fletcher, 1990; Lee, 1994; Voon, 1992; Wright, 1993).

In a summary of six areas of data, Adams (1992) was able to demonstrate a significant improvement of learning styles which compared live instruction with learning via interactive videodisc. The six areas referred to by Adams are: a learning curve to be 60% greater; content retention to be 25-50% higher; learning gains to
exceed 56%; the consistency of learning to be 50-56% better; a reduction in delivery variance of 20-40%; and a compression of a two-day workshop into a one-day self-paced delivery, to be 38-70% faster.

Edwards and Fox (1993) perceive CAL to be unlikely to replace face-to-face teaching and because time spent in the development of software is labour intensive, advocate a need for caution before rushing into its production. Edwards and Fox cited the views of Browser and Sheperd (1991), who believe only a small portion of students prefer technology driven courseware, and Fung, et al., (1991), who investigated the preferences of humanities and engineering students, who ranked computerized instruction as their third least popular teaching-learning activity out of 19 options. However, it was unfortunate that Edwards and Fox presented their admirable questionnaire to gain feedback from students in the week prior to taking their formal examinations. This observation is evidenced by the mere nine out of 200 students and staff respondents who were used to draw these conclusions. From these results, it is clear that the timing and deployment of feedback instruments is imperative to gain valid numbers from a study population.

In an extensive review of national trends associated with, enrolment, tuition, general expenditures, and specific expenditure of students throughout the award of degrees, Snyder and Galambos (1988) addressed serious questions about cost and cost-analyses used in universities in the United States. In essence, this was the second of a two-part report of such trends between 1976-77, and 1985-86. The main conclusion reached by the authors pertinent to this project, was directed at the escalation of non-teaching professionals now found in
academe, which suggests a need for more sophisticated methods to re-assess staffing patterns to determine the most effective deployment of human and material resources. These findings are reinforced by those of Brinkman (1988), who advocates individualised and computer-assisted learning in a paper commissioned to address public concerns about the rising costs of tertiary education.

According to Niemiec, Sikorski, and Walberg (1989), there appears to be overwhelming evidence in support of computer-assisted instruction. These authors affirm that this evidence has been increasing since teaching machines and programmed learning were introduced in the 1950's, removing the repetitive drudgery spent in teaching, leaving such individuals free for higher pursuits. Using previously validated meta-analysis techniques (Aiello & Wolfle, 1980; Kulik, Kulik, & Schwalb, 1985; Bangert-Drowns, Kulik, & Kulik, 1985; Hartley, 1985; Kulik, Kulik, & Bangert-Drowns, 1985; Levin, 1984; McKenna, 1993; and Shmidt, Weinstein, Niemic, & Walberg 1986), Niemiec, et al., (1985) investigated 250 research studies to compare the effects of CAI with traditional tutoring and instruction. Units of standard deviation were applied to the results obtained by both groups. The mean and median effect of CAI were found to be 0.42, with a standard deviation of 0.008, placing the average at the 66th percentile of traditional groups, with a slight variation of the findings of Kulik, Kulik, and Cohen (1980), who found a mean-median effect of 0.4. However, Niemiec, et al., (1985) were able to identify a variation between differing subject matter, especially with a standard deviation of 0.6 when tutoring mathematics. Furthermore, data are presented to compare the cost-effectiveness ratios of CAI with traditional tutoring,
from which it was concluded that CAI can be three times more efficient than tutoring.

In general terms, educational research suggests a knowledge retention rate of 10 to 15% in passive learning situations (Forman, 1994) in contrast to the findings of Lee (1994), who suggested a retention rate of 25% during anatomy lectures. This is varied by Ee (1994) and Wayne (1990), who indicate that audiences recall 20% of what they hear and 80% of what they see. Furthermore, in lecture presentations, Ee and Wayne assert colour to be 32% more effective in attracting reader attention; that colour images attract 36% more readership than black and white; and that a colour format is 25% more effective in causing reader reaction.

Although the findings of Niemiec, et al., (1989) by meta-analysis assert CAI to be three times more effective than tutoring, these results contrast markedly with those of Dean (1989). Dean applied a cost model to compare the use of computers and related software against a control group of faculty members in a university environment. Dean’s model was based on suggestions made by Levin (1984), with a detailed examination of the financial transactions of a computer environment over a four year life expectancy. The overall costs were reduced to a formula which identified the cost per hour of student time at each workstation. Further, these costs were offset against an analysis of the costs of faculty time distributed between control and experimental groups of faculty members. From resultant data Dean was able to conclude that the faculty costs of the experimental group were 21% greater than that of their traditional counterpart. However, it must be pointed out that in Deans analysis, the CAI component was one of enrichment and not
developed to replace traditional methods. From this, it would appear obvious that CAI would be more expensive than traditional tutorial methods. Nevertheless, the formulae and model provided by Dean (1989) and Niemiec, et al., (1989) appear to be valid instruments from which to measure both sides of the CAI-Lecture equation in higher education (Lee, 1994).

These results were further enhanced by Fletcher, Hawley, and Piele (1990), who compared the effects, costs, and utility of computer-assisted instruction with conventional approaches to mathematics for grade 3 and 5 students in the classroom. Perhaps, as is to be expected from a likely Hawthorne effect, both grades of students exposed to CAI attained significantly higher levels of achievement in a test of computer literacy than those who received conventional instruction, whilst the participants from both groups scored similar averages in a survey of mathematical attitudes. Of greater significance in support of this project, was the presentation of data which summarised the cost per month for the students in both grades. In grade 3, a total cost of $20 per student placement per month was identified for the CAI group, as opposed to a total cost of $33 per month for conventional instruction. The same costings were obtained for the grade 5 group, being $17 and $27 respectively. These results contrast with those identified by Levin, Glass, and Meister (1987), who applied a cost analysis for the presentation of 10 minutes per day of four interventions to teach mathematics and reading achievements to adults throughout 1985. The results of this study ranked CAI to be second among four interventions of cost-effectiveness, with preferences given as: a peer or combined tutoring model; CAI; a reduction in class size; and an increase of instructional time. At the time of submission, these authors viewed any
future decline in the costs of hardware as unlikely to compensate for the large proportion of non-hardware costs in CAI services. However, the final sentence of the concluding paragraph declared: 'On the basis of these findings, educators should question unqualified assertions that CAI is a more cost-effective intervention than other alternatives'.

Considering that these studies were undertaken in the mid to late 1980's, the economics in favour of CAI are supported, despite the final reservations made by Levin, et al., (1987). Furthermore, with decreasing acquisition costs of hardware and developments associated with software, together with significant improvements being made in networking technology, the net gain per student on a contemporary basis is likely to favour CAI in an efficient CMLE.

The findings of Levin, et al., (1987), Dean (1989), Niemiec, et al., (1989), and Fletcher, et al., (1990) are reinforced by comparison of the efficacy of two library educational and instructional methods, in which Lawson (1990), assembled test and quantitative data to evaluate the difference between these approaches and CAI models. Because introductory library tours are considered to be more time-consuming than effective with students, the objective of Lawson's study was to find a more effective and less expensive form of library tour. A CAI program was developed to include the same content and objectives as delivered in the normal library tour. The elements of this research were based around 172 first-year engineering students, divided into three groups to assist them to become better acquainted with the skills needed to conduct general research in a one-hour library orientation tour. One group reviewed the CAI program, another the traditional library tour, the third was considered to be the control group and
received no instruction. Pre and posttests were administered to all three groups to measure and compare their level of knowledge and related skills. The results of the study identified that the vast majority of CAI students learned as much as, if not more, than those who used the traditional method. However, of more importance, was the analysis of costs applied to the project. To arrive at the costs of the traditional library induction tour, the librarian’s time was established by the median step of a 12-month salary ranked on an hourly format. The same regime was applied to the teaching faculty, except that it was determined by a 9-month salary ranked down to an hourly format. An elaborate debate focused upon the elements of these two groups, which exceed the requirements of this thesis. However, it did provide an excellent model of operation from which to determine a suitable method of analysis for staff salaries in a research project. The same approach was taken to the CAI component. This included the cost of; hardware; floppy disks; software; user manual; salaried costs per hour of programmer time; service cost of the hardware; cost of the computer-laboratory assistant; and break-down of annual maintenance costs which included two hours of programmer time, replacement of three floppy disks per computer per year, and an annual maintenance charge of $50 per computer. Of greater interest, was that these items were deployed around a system of salaries and cost-models presented in tabular form, spread over a period of five years, each of which was given an increment of five percent per annum. From these data, Lawson was able to conclude CAI programs to be more effective than the conventional library tour provided there was a commitment to purchase sufficient computer work stations over a five year period. Nevertheless, despite these conclusions, it would seem necessary to indicate, that once constructed, the content of a CAI program of library
induction is less likely to require a significant restructuring per annum than the content of an academic curriculum.

As previously mentioned in Section 2.28, Lee & Allison (1993) compared the presentation of identical neuro-anatomical information to randomly selected and evenly distributed second year physiotherapy students, to 41 by lectures and 37 by ICALP. At pretest, the mean for each group was 43.58% and 44.81%, with a standard deviation of 8.67% and 6.54% respectively. At posttest, the lecture group achieved a mean of 73.19%, with a 7.76% SD, whilst the ICALP group achieved a mean of 75.42%, with a SD of 6.76%. The same test was unexpectedly re-administered after delayed periods of 60 and 120 days to both groups. The lecture group obtained 68.04%, with a SD of 8.49% after 60 days, and 68.06% and 8.24% after 120 days. The ICALP group achieved 70.34%, with a SD of 9.58% after 60 days, and 69.68% and 9.02% after 120 days (Lee & Allison, 1993; Lee, 1994). From these results, Lee (1994) was able to assert with confidence that ICALP, Test and FeedBack Items can be used with confidence to teach anatomy at the tertiary level.

However, Glaister (1994) reiterated the views of Edwards and Fox (1993) by advocating caution prior to launching into the development of interactive courseware when describing the time taken to construct two computer driven learning modules for two hours of student interaction. Thus, the developmental process of two modules for two student hours of interaction, took 110 hours to develop, representing a ratio 55:1. However, this proved to be a minimalist estimate because considerably more hours were spent later in processes of modification and re-development. Furthermore, Glaister cited Brown (1991) and
Canale and Wills (1993), who showed a time ratio of 217:1 for the development of CBL courseware in a cost range of $10,000 to $20,000 before completion.

2.38 Comparative cost-effectiveness

In a statement which may be applied as a principle of operations sixty years later, Robins (1935), defined economics to be: 'the science which studies human behaviour as a relationship between ends and scarce means which have alternate uses'.

According to Blaug (1970), Robins subscribed to a scientific view of economic discipline, which may be applied to educational planning. From this standpoint, Blaug (1970) proposed a hierarchy of five elements which may be applied when making important economic decisions in education. In brief, these were: How much of the total resources of an economy should be devoted to education? How much should we spend on education out of the government budget, relying on private finance to fill out the rest? How should we divide public expenditure on education between formal education provided by educational institutions and informal education provided by industry and various government agencies? How should we divide public expenditure on formal education between the different levels of the educational system? How should we divide public expenditures on formal education at a particular level between institutions? Even though Blaug's hierarchy addresses the economics of education at a national level, its principles may be applied to meet the needs of large institutions, or sub-categories within them.
Although the concepts of cost-benefit and cost-effectiveness have been in vogue to economists since the turn of the century, it was not until the mid-1950's that these techniques were applied to healthcare, the housing industry, town-planning, and education, where it may be referred to as a rate-of-return analysis (Prest & Turvey, 1965; Hough, 1967; Blaug, 1970). In a more recent time sequence, Conyer (1992) studied the progress of eleven professionals in the development of computerized learning modules, finding the end product to be in a ratio of 200:1, affirmed by Reeves (1995).

In a comparative study, Lee and Allison (1992) defined the ratio of time spent in the development of ICALP to time spent by its users, to vary between 50:1 and 100:1 dependent upon the complexity of the package. Whereas, Glaister (1994) took 110 hours to develop two computerized modules each for a one hour presentation, representing a ratio 55:1. Whilst Brown (1991) and Canale and Wills (1993), showed a time ratio of 217:1 for the development of CBL courseware in a cost range of $10,000 to $20,000 before completion. However, these findings may be empirically off-set by the 'rule of thumb' which suggest it takes one hour of research and experience to fill each minute of a traditional lecture (Lee, 1994).

Further evidence may be obtained from Jones, et al., (1978) and Walsh and Bohn (1990), who compared medical students in traditional classes with those using computers to show that both groups could learn gross anatomy equally well without lectures or dissection, and Lee & Allison (1992) who could find no significant differences between randomly selected groups of physiotherapy students whilst learning anatomy of the lower limbs, either from lectures or by ICALP. In addition, these
results were validated by replication studies in neuro and cardio-pulmonary anatomy to subsequent student groups (Lee, 1994) which verifies the cost-effectiveness of ICALP with traditional lectures when learning anatomy by physiotherapy students (Lee, 1994; Lee & Allison, 1992 & 1993; Lee & Kemp, 1994). In this way, these data provide models of cost-effectiveness for the administration, maintenance, development of software, and use of work-stations in a CMLE (Lee, 1994).

2.39 Specific cost-effectiveness
The advances of interactive multimedia technology have furnished educators and learners with improved options for the presentation and absorption of information. However, the costs of producing interactive courseware is determined by major life-cycle items of hardware and software, the economics of which can be effectively analysed by the model published by Tan and Nguyen (1992). Nevertheless, caution is advocated in the use of computers to reach more students with fewer resources (Glaister, 1994; Kingsland, 1994). Much research has indicated an enormous investment of time and effort in the development of CAL materials (Brown, 1991; Cochrane, Ellis, & Johnston, 1993, Reeves, 1995) with a need to justify budget models over a prolonged period of time (Foster, 1988; Kingsland, 1992).

As previously described in Section 2.23, when learning anatomy by computer, Walsh & Bohn (1990) advocate the use of computer-assisted learning to replace some existing lectures which would release the lecturers time for other purposes recommended by Muller (1984). In a comparison of the educational cost-effectiveness of traditional lectures with SOCCER in a CMLE, Lee (1994) elucidated the recorded...
activities of staff and students in the School of Physiotherapy at Curtin University for the previous four years. These data compared the cost-effectiveness of ICALP modules with lectures for the teaching and learning of anatomy. Models of cost-effectiveness were applied to the administration, maintenance, development of software, and the use of work-stations in the CMLE. The educational cost-effectiveness of SOCCER was used to compare the results of lecture and computer learning groups. Techniques were described to continuously register, score, record, store and retrieve results for instant review by learners and administrators over a prolonged period. Usage was audited to appropriate the share of the total running costs of the CMLE to rate the cost per hour of each student at a work-station when learning and being tested for comparison with the time spent on the preparation of lectures with the development of software. Estimates of the time taken to prepare lectures, assignments, written and practical examinations, as well as to grade these procedures was compared with the time taken to develop ICALP’s, test and feedback items, and the tracking, recording and retrieval of results. The educational cost-effectiveness of these models was measured in units per hour to compare the effectiveness of students attending lectures with their counterpart at computer workstations. The effectiveness of CBL was validated by comparison of pre and posttests with the retention of the knowledge in delayed posttests at 60 and 120 day intervals (Lee, 1994; Lee & Allison, 1993). This information was collated to demonstrate the relative cost-effectiveness of computer-based learning with lecture methods (Lee, 1994), the details of which are to be found in Chapter 5 (p 266).
2.40 Learning curve and cost-effectiveness

Offir and Katz (1990), provided a learning curve model to evaluate the
cost-effectiveness of computerized learning programs. These authors
suggest that educators use philosophy and theory in their decision-
making process, whereas educational administrators and economists
base their decisions upon cost-effectiveness. Lee and Allison (1993),
compared the cost-effectiveness of traditional lectures with computer-
assisted learning, to confirm that ICALP equates with lectures,
enhancing them to seminar-discussion sessions with problem-based
learning sooner than may otherwise be expected.

2.41 SUMMARY

This chapter commenced to highlight the epistemology of education and
substantiate the use of a Socratic style of dialectic with Aristotelian
syllogisms to invoke an autonomous learning model during the
development of software throughout this project. In the same way, a
review of preliminary behaviourist educational psychology was
undertaken to compare a mechanistic approach to teaching machines
with the evolution of contemporary computer-based learning
techniques. This review was continued to pursue the principles of open
learning theory and Gestalt education to verify their use in this project
to stimulate a life-long commitment to continued education by its
subjects.

This review also identified a need for the active engagement of the
learner in a computerized open educational process, to be enhanced by
the instant feedback of accumulated results to foster an environment of
positive reinforcement. In this domain, note was taken to avoid the
counterproductive risks of a Hawthorne effect by introduction of a well
regulated scheme of randomised rotation among learning sub-groups throughout this project. To inaugurate self-actualised learning, note was taken of literature related to the progressive stages of learning from pedagogy to andragogy. In this way, the literature was applied to establish a sense of individual control and rate of personal progress by the learner at all stages throughout the period of this thesis.

The controversial issues associated with examinations and grading schemes were also reviewed to authenticate the feedback modalities and problem-based learning styles which were incorporated into this study. This information was used to generate a sense of empowered acceptance and personal responsibility for the quality of the outcomes by the learners involved in this project.

The exponential growth of information introduced by the advent of computer technology in higher education was also reviewed, with special consideration given to its intuitive use in medical education generally, and anatomy specifically. During this process, the history of computer-based learning was related to nursing, dentistry, medicine, biomedical education, allied health, and continued education was also considered. To gain a firm base for this project, reviews were undertaken of meta-analysis techniques and effect sizes of educational groups to evaluate the impact of computer-assisted learning with classroom teaching in anatomy at the tertiary level.

This chapter also focused upon general and specific methods applied in the selection of physiotherapy students to correlate this information with subsequent success in anatomical studies to meet the requirements of a quality-assured professional qualification. This review also
investigated the group embedded figures test for its possible use to predicate the likelihood of success in the anatomy component of an undergraduate physiotherapy education. Finally, to meet the requirements of this thesis, literature was also reviewed to relate the cost-effectiveness and cost-benefits of computer-based learning for comparison with the outcomes of traditional methods in higher education.

Despite the findings of this complex literature review, a need was perceived to provide authentic replicated data to validate the benefits of ICALP materials presented by SOCCER to verify their use in a self-actualised, problem-based, learning environment as an alternative to traditional lectures in anatomy to undergraduate physiotherapy students.
CHAPTER 3

THE DEVELOPMENT OF INSTRUMENTS

3.1 The evolution of an educational philosophy by this author
Throughout the past two decades, the basic philosophy for the teaching and learning of anatomy in the School of Physiotherapy at Shenton Park, Western Australia, has been directed towards the development of a student centred self-directed autonomy of learning by this author. This philosophy is the outcome of experiences gained as a student and member of staff in the Department of Anatomy at Manchester University in the United Kingdom; the Department of Anatomy at the University of Toronto; the Ontario Institute for Studies in Education, University of Toronto; and the Department of Anatomy in the Faculty of Medicine at McMaster University, Canada. All of these institutions progressively inspired a view of student centred learning, dependent upon well-conducted facilitation by lecturers and resource persons, in an environment rich in resources.

3.2 The initial learning environment in anatomy at Curtin
The original environment for learning anatomy by first and second year students in the School of Physiotherapy, at Shenton Park, was distinctly focused upon the outcome of three and two hours of lectures per week respectively. These lectures were supported by one-hour medium sized tutorial groups in first and second year, with a two-hour laboratory session per week for first year students, and a one and a half-hour laboratory session per week for second year students. The lecturer and tutors acted as demonstrators in small-group laboratory sessions.
3.3 Labour intensity and economic rationalism
With a steady increase in student enrolment averaging 45 students in the mid 1970's rising to 85+ in the early 1990's, the running costs of the initial learning environment became prohibitive, requiring a converse reduction in staff and resources. With the advent of economic rationalism in the period of 1980-85, all tutors and tutorials were dispensed with and the distribution of lectures between first and second year groups were reversed. Thus, lectures in anatomy to first year students were reduced from three hours per week to two, whilst the time allocated for anatomy lectures to second year students was increased to three hours per week. Unfortunately the apparent gain by second year students was neutralised by the inclusion of pathology, which had previously been dealt with as a separate entity in another part of the curriculum. In effect, there had been a net loss of direct student contact with the lecturer and definitive support from tutors and laboratory demonstrators. In this scenario, the lecturer delivered five hours of lectures to first and second year students of anatomy and pathology per week, assisted by two other support persons to meet the needs of six two-hour laboratory groups of up to thirty students in each group.

3.4. Progression of the learning environment for anatomy
Despite the depletion of staff and resources, compensatory efforts were made to sustain a self-paced style of learning in anatomy by the development of inexpensive laboratory manuals made available to students at the campus bookstore, combined with stand-alone slide-tape learning packages. These learning packages were deployed to supplement lectures at ten 'Caramate' workstations in a learning centre administered by the Library staff at Shenton Park.
These resources were further supplemented by the careful assembly of text, video and graphic materials administered by the library staff at Shenton Park.

3.5 Prevalent examination techniques
Throughout these changes in the learning environment for anatomy and pathology at Shenton Park, the main stimulus to student learning was maintained in an atmosphere of admonition by examination. This entailed two, two-hour laboratory examinations per semester. Each of these two-hour sessions was applied as mid and end of semester practical examinations interspersed by unpredictable laboratory quizzes capped by a formal two-hour written examination at the end of the semester.

Although the standard of selection of students for the physiotherapy program maintained a normal rate of excellence, individual progression was fraught with hazard and rote learning in anatomy to meet the demands of this archaic examination system. Furthermore, in such a system, it proved difficult to engender a genuine feeling of secure autonomy in a self-directed learning environment.

3.6 Coincidental hardware
Purely by chance, in 1989, a coincidental windfall of $A32,000.00 was made available to the Schools of Occupational Therapy and Physiotherapy at Shenton Park. It was decided that this money would be allocated to the purchase of 20 basic computers, later supplemented by obsolescent machines discarded by academic staff as they obtained more advanced machines. These computers were installed as a network
of 25 workstations in a separate room served by an already established central computer system operated by a Network Administrator.

Initially, these computers were harnessed into a network with two objectives in mind: firstly, to familiarize senior students with the use of computers as word-processors; secondly, to enable them to reach a more professional standard of presentation when preparing assignments and research projects.

Soon, these workstations were augmented by a transportable trolley housing a computer-driven overhead projection device driven by a black and white software application known as DataShow®. Eventually, the DataShow trolley was reserved for small-group lectures and learning, was replaced by Microsoft® PowerPoint® software in a colour format for over-head projection in a large lecture theatre.

As the impact of computer driven workstations became evident to this author, the possibilities for the delivery of learning materials to autonomous self-paced students from his own desktop computer became clear. This dimension was reinforced by the possibility of over-head projection of the same learning materials to small and large lecture groups by DataShow® and Microsoft® PowerPoint®.

These beginnings gave origin to the development of a Computer-Managed Learning Environment to promote an autonomous style of self-paced learning in anatomy and pathology on the Shenton Park campus.
3.7 A concept of computer-driven learning packages
Once the concept of a CMLE was envisioned, there was a need to develop suitable software to meet its requirements. The anatomy syllabus was reviewed and reduced into manageable components. These components were constructed as a story-board of items to be developed sequentially according to the anatomy syllabus. Once identified, these items were related to the structure and function of well-defined areas of the body. As they were developed, the parochial learning items became known as Interactive Computer Assisted Learning Packages (ICALPs) for the delivery of information about the structure and function of specific anatomical regions.

3.8 Software development
To coincide with the logic of a traditional anatomy syllabus, ICALP materials were originally developed as distinct items for presentation in a linear sequence, starting with the lower and upper extremities, trunk and back, head and neck, cardio-respiratory system, and central and peripheral nervous systems. As these packages evolved, so did their level of complexity and interest, giving way to an integrated regime of structure, function, and dysfunction. Simultaneously, attention was given to the development of test and feedback instruments to link the evolution of ICALP materials into a non-linear format.

3.9 A computer-managed learning environment
At the outset of this project in 1989-90, an expanding list of separate ICALP modules was presented to learners as an alphabetical list of topics at each of the workstations of the CMLE. Each item was referred to as a node. With the cooperation of the Network Administrator, nodes were made available at the workstations in the
CMLE from the desktop of the Subject Controller. In this way, *ResEdit* (remote console) privileges empowered the Subject Controller to monitor, regulate, and retrieve data at anytime from each of the workstations in the CMLE.

### 3.10 Nodes

Using these privileges, an ICALP-Shell was developed as a stem for each learning module, classified as a node. Initially, nodes were deployed separately to enable prescribed users to gain free access to them in the CMLE.

### 3.11 Tests

ICALP nodes were readily converted into test devices by the duplication of selected diagrams to be assembled into an *ad hoc* string of electronic screens scripted with the question and scoring techniques described below. These questions were presented in various ways to challenge the intellect of the learner, namely: as intrinsic questions within a learning node; as a string of the same style of questions in formal or informal test situations; as multiple choice test items; and as true-false test items.

### 3.12 OHP

By virtue of *DataShow* and *Microsoft® PowerPoint®,* ICALP nodes were readily converted into overhead projections (OHP) to present the same information in a lecture format, allowing the lecturer to navigate through the material as desired, placing emphasis upon certain topics or themes, with verbal direction to learners who wished to revise or reinforce the information independently in the CMLE. It soon became self-evident that this technique could be applied as an effective
educational research instrument to investigate and compare the abilities of those who learn entirely by lecture with those selected to do so by computer.

3.13 SOCCER
By 1992, the linear presentation of ICALP and evaluation items was considered restrictive, leading to a more vigorous investigation of other methods of presentation. Fortuitously, this author was awarded a small grant by the Committee for the Advancement of University Teaching (CAUT) in Australia to investigate methods to provide self-paced learners with computerized pathways of learning. The principal outcome of this particular CAUT grant was the development of a Self Operated Computer Controlled Educational Resource (SOCCER). The principle of SOCCER is to provide a non linear format to present an unlimited number of nodes and test items to empower learners to become self-paced and self-directed.

In this way, SOCCER not only provides a universal platform of entry to a multiplicity of learning nodes, but is also able to register, monitor and track learner activities during the validation of each level of performance. SOCCER is a comprehensive navigational instrument to a network of black and white workstations. To meet the needs of colour operated workstations, SOCCER can be converted from HyperCard® to a SuperCard™ format on an Apple® Macintosh computer, with additional input from MacroMind Director® and QuickTime® to blend video-clips and direct photographic images from a QuickTake® 100 digital camera. In this mode, SOCCER would be referred to as a Student Controlled Learning and Assessment Resource (ScoLar).
3.14 Registration in SOCCER by unique password
On entry to SOCCER, learners are categorised by their inclusion in a
draw-down list and presentation of a unique password. An abundant
supply of passwords is stored for presentation at the first time of
registration, for collation of data obtained thereafter. In this way,
SOCkker provides each learner with a permanent registration and
opportunities for revision and learning and entry to test and feedback
items to verify their status at all levels of entry. Passwords may be
retained throughout a whole course of study, or varied daily, according
to any need for change.

![User Name: List](image)

**SOCCKER**

Self Operated Computer Controlled Educational Resource

![Australia Map](image)

by

Harry B. Lee

Curtin University

July,1993

[Quit SOCCER][Click Here to Start]

Figure 1. Entry to SOCCER for registration and learning activities.

Figure 1 shows the first screen of entry to SOCCER, which was
launched in July, 1993. To acknowledge its origin, SOCCER is
identified by a logo depicted by a map of Australia enclosing the term
CAUT as an acronym. After a few seconds a five point dialogue box is shown on the first screen of SOCCER, as seen in Figure 2.

Figure 2. Message box to facilitate entry to SOCCER.

The five point dialogue box invites the learner to point the cursor to the user name list at the top left of the screen, then asks for the mouse to be held down over it until a course list appears to enable the learner to select a course title and user name list, which requires a click on it to show another dialogue box. In effect, the user name list is an invisible field which is scripted to reveal a Draw-Down List of ‘hot-spots’ containing course titles and personal names as a PopUpMenu seen in sequence in Figures 3 to 9.

Figure 3 shows the fingertip of the browsing tool directed at the User Name List where the mouse is held down to show a list of ten options.
In this example, the postgraduate manipulative therapy list of 1993 is given to illustrate this part of the sequence shown in Figure 4.

Once the Postgraduate Graduate Manipulative Therapy list is highlighted, the cursor is moved to the right to reveal a draw-down list of that course, italicised in Figure 5. Moving the cursor to the right, reveals the *Post Grad Manips* course list where Jenny Sinclair may be applied as an example to illustrate this strategy in Figure 6. When Jenny has clicked on her name, as shown in italics in Figure 7, a further dialogue box of welcome appears, as shown in Figure 8.

It is important to note, that on the first point of entry for each student to SOCCER, an individual dialogue box appears to inform the learner of a specific password which has been selected to register all activities thereafter. The coordination of names with unique passwords may be observed by those allocated to academic staff in Figure 45, for first year undergraduates in Figure 46, and for postgraduates in Figure 47.

Although this important function is vested in the framework of SOCCER, the detail of its process is only available to the Subject Controller and Network Administrator, remaining hidden to the user throughout all activities. If these procedures are followed correctly, then the name, date, start and finish-time, together with the detail of any achievement, is registered via external commands (XCMDs) and functions (XFCNs) to be recorded as information in an individual *Microsoft® Excel®* file. Immediately thereafter, these results are mutually available to the learner and Subject Controller, as shown in Figures 12, 50 and 86.
As will be observed from Figure 9, Jenny Sinclair was able to complete this task successfully by typing in her password, ORCHID. At this point, SOCCER is scripted to move the learner to the screen allocated to that particular course, which is Figure 10 in this case. Figure 10 shows the logo diagram for the Manipulative Therapy Menu, superimposed by title buttons scripted to take the learner to the themes shown.

![Image of SOCCER logo]

**Figure 3. Cursor entry to show course list.**
Figure 4. User selection from course draw-down list.

Figure 5. Selection of Post Grad Manips from course draw-down list.
Figure 6. Draw-down Post Grad Manips user list.

Figure 7. Selection of Jenny Sinclair from the Post Grad Manips list.
Figure 8. Welcome to Jenny with an invitation to register by password.

Figure 9. Registration of Jenny by ORCHID.
3.15 Mutual access to SOCCER

The educational power of SOCCER is found in its ability to faithfully and continuously register all of the activities undertaken by each individual learner throughout the sum of their activities in the CMLE. This facility is enhanced by the mutual ability of the learner and restricted staff members to monitor the events of such individual progress.

Throughout this project, access by staff to learner records was severely limited to those closely involved with the process. Figure 11 shows the menu available to staff members awarded this privilege. Once allowed access to the Admin Menu, such personnel may gain unrestricted access to all of the privileges shown on the screen in Figure 11, or may be restricted to only one, or a few items, when de-selected items would be
programmed to remain invisible to them according to the level of their entry procedures. In the case of Figure 11, all privileges are exposed. In such a situation, academic and administrative staff may explore any of the learning materials available to each course, as well as review the cumulative efforts of any of the learners using SOCCER.

A click on Exam Results Summary would enable the staff member to scroll down the list of learners in a particular course, then select a particular name to review the quality of their activities shown in the Previous Results Browser shown in Figure 12. Using the cumulative data shown in Figure 12, each learner can instantly see the results of their efforts throughout any designated learning period. This information summarises the data obtained at the end of ICALP session, such as in Figure 77, showing the date of access, the length of time spent on each activity, with an account of the number of clicks applied during each event, the number of errors made whilst doing so, as well as the total number of cards seen on that occasion, and summary score obtained. Other columns account for MCQTI's, TFTI's and FeedBack items, not shown in the example given in Figure 12.

3.16 Approach to materials in SOCCER
Once registered, the learner is taken to a prescribed level of learning, with appropriate test and feedback items via a primary screen. Thus, the Subject Controller can prescribe the parameters of learning designated by each route of entry. Using the techniques already described, at entry, the course level of learning is registered, the individual is identified by a unique password with freedom of access to designated facilities dispensed by SOCCER. Figure 13 demonstrates the primary screen of access to a first year entrant, with second, third,
and post graduate screens of opportunity shown in Figures 17, 39, 40 to 44 respectively.

3.17 Primary and secondary themes

SOCGER enables learners to navigate freely from the point of entry throughout a prescribed syllabus. The primary themes of learning already described are to be found in Figures 17, 39, and 40 to 44, provide access to secondary subdivisions. As an example, the primary screen of access open to a first year student is shown by Figure 13. The primary screen contains secondary methods of access to the upper extremity, trunk, lower extremity, and an examination results summary. Such a primary screen can be varied to meet the changing conditions of an evolving syllabus and use of evaluation devices by the application of appropriate buttons from the desktop in the office of the Subject Controller. In this way, a click on 'upper extremity' shown in Figure 13 gives access to secondary themes of learning grouped in Figure 14 as, 'shoulder-arm', 'arm-forearm', 'forearm-hand'.

3.18 Hot regions

To sustain interest, the transition displayed by clicking from the point of entry to primary and secondary themes illustrated by Figures 1 to 14, is enhanced by 'hot regions' scripted to transport the learner to further designated screens. This strategy was designed to give interest as well as a subtle illusion of change by the appearance of an area of demarcation. For example, using the anatomical sketches shown in Figure 14, when the browsing tool is moved across the shoulder, arm, forearm, or hand, it activates transparent buttons which are scripted to respond by automatically taking the user to a further screen of opportunity. Hence, the learner is only required to move the cursor
shown in Figure 14 over to the shoulder region, which is covered by 'hot spot' buttons scripted to change the screen to Figure 15. To complete the operation, the learner is merely required to click on any shoulder region displayed in Figure 15 to go directly to the ShArm ICALP displayed in Figure 51.

Should the learner wish to return from a secondary to a primary theme, this facility is provided for by the strategic use of 'hot spot' hand arrows shown in Figure 16, which are scripted to return the user to Figures 14 and 13 respectively.

Further examples of transition are shown for second year learners in Figure 17. Figure 17 represents a primary theme offering nodes of access to secondary themes, according to the syllabus in use at that period of time. In this case, the learner has access to all ICALP materials previously used in first year together with more advanced modules for those regions. Other topics shown represent the gradual growth of further themes as they become appropriate to the course, such as the heart and lungs, or bone and joint pathology. The primary screen in Figure 17 also shows how a more advanced second year learner may gain access to specific problem topics, which will be described later. Figure 18 shows the entry of a second year learner to an array of learning themes related to the central nervous system. Hence, Figure 19 shows access to seven ICALPs of the central nervous system.

The logo has been reversed to dramatise the effect, whilst leaving the learner to either select a particular ICALP, or return to the options displayed in Figure 18 by moving the cursor over the 'hot spot' hand
arrow. To exemplify the return option, the learner can use the 'hot spot' to get back to the second year primary screen to select an investigation of secondary options for the peripheral nervous system, as shown in Figure 20. Figure 21 shows the range of options available to a second year learner at that particular time. These secondary options empower the learner to investigate the embryology and development of the peripheral nervous system, entitled EmbPerNerve, or to learn about nerve lesions, reflexes, the brachial plexus, or the lumbosacral plexus. Figure 21 shows the browsing tool of a second year student who wishes to investigate an ICALP related to the brachial plexus, whereas Figure 22 illustrates the activities of another learner who wishes to go to the ICALP related to reflexes.

3.19 Animation
To add further interest and innovation, some SOCCER screens are linked to give an illusion of animation for a particular purpose. Entry to the ICALP about reflexes exemplifies this facility, which is illustrated by Figures 22, 23 and 24. A click on 'reflexes' in Figure 22 is scripted to repetitively change several screens which dissolve into a final screen before entry to the ICALP for reflexes. In this way, an illusion of animation is created to surprise the learner by the combination of elbow, knee, head and neck movements shown between Figures 23 and 24. The penultimate screen shows the subject with a puzzled facial expression, before dissolving into the ICALP for reflexes.
Figure 11. Menu available to administrative and academic staff.

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<th>Date</th>
<th>Time(mins)</th>
<th>CALP/Test Title</th>
<th>Category</th>
<th>Error</th>
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<th>Clicks</th>
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<td>81.5%</td>
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<td></td>
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Figure 12. Previous results browser available to individual learners and authorized administrative academic staff.
Figure 13. Menu available to UG1 learners. In this case with selection to ICALPs of the upper extremity.

Figure 14. Hot-spot regional anatomy available to first year learners.
Figure 15. Invitation to click on the shoulder and arm to open its ICALP.

Figure 16. Hot-Spot return arrow for re-entry to Figure 14.
Figure 17. Screen of opportunity for second year learners.

Figure 18. Entry to an array of ICALPs related to the CNS.
Figure 19. Range of ICALP options of learning about the CNS.

Figure 20. A second year learner wishes to investigate the peripheral nervous system.
Figure 21. Options about the peripheral nervous system. In this case the learner wishes to explore the brachial plexus.

Figure 22. The learner intends to investigate reflexes.
Figure 23. An animated transition between this screen and Figure 24.

Figure 24. An illusion of reflex movement on the right side of the subject.
3.20 Laminations of access
Using the techniques previously described, alongside those suggested by Figures 25, 26, 37 and 38, the learner is provided with a variety of devices to explore an unlimited number of laminated pathways from primary to secondary themes to the nodes of ICALP materials within SOCCER at workstations in the CMLE.

3.21 Properties of an ICALP shell
As the School of Physiotherapy at Shenton Park did not plan to upgrade its network of workstations to a colour mode until after the mid 1990's, the production of ICALP materials for the anatomy syllabus was based upon a HyperCard®-Shell in a black and white format. This Basic-Shell consists of ten cards; a Title card; a Confirmation of entry card; a Scrolling Core of References card; a Help-Menu card; an Introductory-Information card; a Reference card with a scroll-up menu of sources used; a Main-Menu-Glossary card; a Plain-Learning card; a Complex-Learning card; and a Summary-Score card.

3.22 Title card
The first card of the ICALP-Shell is blank but ready to be pasted with a logo and titles of origin to identify it as a future learning package. As an example, observe Figure 51, which shows the title of the package at the upper right side, with the name of its originator and date below it. In this way, titles can be dropped into blank fields already located on the first card of an ICALP-Shell. In this case, the learning package was designed to cover the structure and function of the shoulder and arm of the upper extremity, its title was foreshortened to read ShArm+. The presence of a + sign after the title was used to indicate a package programmed with hand arrows for positive reinforcement. Once
accepted for registration into SOCCER the user can proceed to the first screen of a particular ICALP, where a button entitled 'Click Here to Start' is scripted to convey the learner to the next screen. Should the learner wish to terminate the process at this point, an exit button facilitates escape from the ICALP in question.

3.23 Confirmation of entry
The second screen of an ICALP-Shell is designed to confirm the location and title of the current item to the learner. Figure 52 serves as a an example of this card, it merely contains a blank field into which the title and purpose of the ICALP can readily be inserted. This card also contains standard buttons, already scripted and located, to enable the program developer to go on.

3.24 Scrolling core of references
The third screen in a standard ICALP-Shell is one which includes a scrolling field containing a core of references and source material used to make any ICALP. Figure 53 exemplifies this technique, which has been modified to give the particular sources used in the development of the ShArm+ ICALP.

3.25 Help-Menu card
Figure 54 represents the standard content of a Help-Menu card. This card consists of a background field with the icons of standard navigational buttons and fields superimposed upon it. Forward and backward arrows are illustrated to show how to move through the stack. ‘Show’ and ‘Hide’ buttons are described, which can be used to either show, or hide fields on a Complex-Learning card. A ‘Main’ button is included which can be clicked to go to the Main-Menu-
Glossary card. In this format it is merely used for demonstration purposes, and is programmed to operate for a period of 3 seconds, then to return to the Help-Menu card. A ‘Help’ button is included, which allows the user to review this card from any other within the stack. A ‘MouseDown’ button is described, which directs the user to click and hold the cursor onto it, causing the appearance of another instructional image whilst doing so. An edited icon resembling an eyeball in an orbital slit, entitled ‘Information-Iris’ (I-I), is shown with instructions for the user to practice MouseDown clicks onto it. When the I-I is clicked, a PopUpField is revealed which is loaded with instructional information, naturally it is scripted to disappear on MouseUp. Finally, a ‘Q’ icon is shown, which demonstrates how to Quit HyperCard© without penalty at any point throughout the stack.

3.26 Main-menu-glossary card
A scrolling text window demonstrates the 'Main' card in Figure 55. This card contains a standard field scripted to show a scrolling list of particular learning screens within the stack. As each screen is developed from the ICALP-Shell, it is given a concept title, which is scripted to become a 'hot spot' within the text window. In effect, the scrolling text window becomes an index of content to each ICALP, which enables the learner to find a particular concept, then click on it to go directly to that card. Alternately, the learner may wish to proceed in a linear fashion, a task performed by clicking on the forward arrow at the bottom right of the screen. In the same way, the learner can go back to the previous screen by clicking on the reverse arrow shown at the bottom left, or quit by clicking on the 'Q' icon.
3.27 Plain-learning card

As a labour saving device, a Plain-Learning card is included within a standard ICALP-Shell, containing the basic items already mentioned in the Help-Menu above. This learning card can be copied into a new stack to include graphic information, Hide and Show icons, an I-I field of information, a MouseDown facility to allow the learner to view graphic information in another dimension, together with icon buttons scripted to go back to Main, with forward or backward arrows for navigational purposes. With experience, the plain learning card can be developed to become the source of a great deal of information, enabling the user to work freely within the stack for further review.

The essential component of all ICALP modules is that the user is provoked to answer a challenging question before being allowed to work forwards throughout a stack. This is achieved by scripting the forward arrow to hide all other information and to show a dialogue field which contains a specific question about a concept described within the learning card. If uncertain, to avoid penalty, the learner can click on the ‘Hide’ icon to remove the question, and then search for the answer among the information already available on the learning card. When ready, the learner can try again. The question may merely ask the learner to click on a specific target within the diagram, or may require the learner to discriminate between several choices, only one of which is correct. The correct target to answer the challenging question is superimposed by a transparent button which, when accurately clicked, allows the learner to proceed to the next card without penalty. In early ICALP models, if an error occurs nothing happens. However, later and more sophisticated ICALPs included flashing hand arrows of positive reinforcement (Figures 65 and 83).
To comply with a classical 'true-false' scoring system, up to three errors are allowed on each card. After a third erroneous attempt, indicator arrows are scripted to appear to outline the target (Figures 65 and 83). To reinforce the learning process, a click must be made on the target zone to move on to the next card. In this way, plain-learning cards can meet the requirements of an ICALP stack by interactively challenging the user to a higher level of activity.

3.28 Examples of plain-learning cards

The evolution of a collection of plain-learning cards is exemplified by Figures 60 to 68. Figure 60 shows gives a sectional view of the right shoulder joint. The basic features of this region are shown in relationship to each other. A field of injunction at the top left of the screen invites the user to perform certain tasks. In this case, it invites the learner to explore the ten items indicated from A to J, open the I-I, and to do a MouseDown. As already mentioned, the user is able to open each item separately, or collectively, by clicking directly onto each letter or the 'show' icon. In this way, simple structures may be identified and further delineated by the conceptual content found in the field initiated by a click on the I-I icon.

Figure 61 shows the result of a click on the I-I icon in Figure 60. The I-I field is scripted to respond to a 'hold-down' mode while using it, however, it is also scripted to remain on the screen if the cursor is moved onto it. This technique enables the learner to used both hands to make any notes and then remove the I-I field by a further click on the I-I icon. In this case, the learner is informed about important concepts of palpation related to the structure and function of the shoulder joint, as well as a reminder to use the MouseDown option to get a view of the
region from another perspective, as shown in Figure 63. In this way, simple learning cards can be assembled to link important concepts together.

Figure 62 shows the result of clicking on the forward arrow at the bottom right hand corner of the card. In effect, the forward arrow is a button scripted to show a field containing a challenging question about a concept already under discussion. As mentioned before, the script of the forward arrow also includes a command to hide all other information from view. In this case, the learner is invited to click where the tendon of subscapularis may be palpated. At this stage, if in doubt, the user can merely click on the 'show' icon to remove the question without any risk of penalty, at the same time showing all ten of the learning fields to revise the information and find the solution. Alternatively, if already confident about the location required, the learner may pursue the target. The target area is precisely delineated by transparent buttons to take the user to the next card if clicked correctly. In this case, the learner is successfully taken to the screen already observed in the MouseDown interactivity viewed between Figures 62 and 63.

In Figure 63 the learner retains all of the options previously mentioned and, when ready, is likely to click on the forward arrow to hide all other information and show the challenging question. The question is shown in Figure 64, asks the learner to click on a muscle innervated by the thoracodorsal nerve. Unfortunately in this case, the learner is unable to precisely identify the target area after three erroneous attempts. As a consequence, the correct solution to the question is outlined by flashing hand arrows shown in Figure 65. To reinforce the
correct solution to the problem, the learner is then required to click on the target to move on. However, if more information is required, the learner can either use the return arrow to go back as far as necessary, or click on Main go back to the screen containing the scrolling index to investigate the matter from another perspective. In this case, the learner was satisfied and decided to go on from Figure 65 by a response of reinforcement to the muscle innervated by the thoracodorsal nerve. This interaction leads the learner to the next screen, Figure 66, which is a surface view of the right shoulder and arm interspersed by an outline of associated bones and some important nerves.

Figure 66 contains the usual information and interactive opportunities already mentioned, showing a click on the I-I to gain the information shown in Figure 67. The I-I field in Figure 67 is designed to inspire the learner to further action beyond the confines of the CMLE. Such a question is used in a rhetorical framework, similar to that which may be applied to an audience in a large lecture theatre. After the I-I sequence undertaken in Figure 67, the learner has decided to click on the forward arrow to show the question revealed as Figure 68. The question in Figure 68 is designed to stretch the mind of the learner to collate information about the structures previously discussed, and to click on a specific target associated with a particular function.

3.29 Complex-learning cards
Complex-learning cards are a natural extension of the plain-learning card. In the same format as plain-learning cards, complex-learning cards contain up to ten buttons which may be identified by a letter or number, to be arranged around a diagram pasted onto the card. Lines
are drawn to link each button to a specific part of the diagram, as seen in Figures 60, 63, 66, 68 and 71. In the same way, any of the icons found on a plain-learning card may be extended for use in a more complex situation.

Such transition may be observed by looking at the first few screens associated with the Cardio-ICALP represented in Figures 27 to 36. Figure 27 shows a simple logo diagram to represent the content of the Cardio-ICALP, with an invitation to proceed by clicking to start. Figure 28 shows a 'menu of concepts' related to the heart. In effect, each concept is covered by a transparent button scripted to take the learner directly to the screen associated with that structure. Using the elements outlined in Figure 28, the learner is able to either investigate each concept separately and return to this menu by clicking the go back (GB) arrow, or explore the whole structure in a linear format by clicking the arrow shown at the top right hand side of the menu. Because the heart is likely to have been studied by most students previously, this early technique was used to optimize learning opportunities by an open freedom of choice. The same situation applies to the lungs, which would be entered via Figure 37 to study ICALPs related to the structure and function of these organs at a professional level.

At the end of the session, having decided to exit, the learner is automatically presented with the same outline of concepts for revision by being taken to Figure 36 for a MouseDown review. In this case, each concept is covered by a transparent button which is scripted to go to the screen in question and remain there as long as the mouse is held
down. When finished, the learner is able to go to the summary score card, which will be described later.

On first impression, Figure 29 is a straightforward diagrammatic representation of the anterior aspect of the heart and lungs within the thorax. However, at the bottom right is an invitation for the learner to click on each part for more information. Hence, this screen is empowered to enable the learner to discover where to locate the heart, that its root is at the top, with its base wider and transversely arranged below it, and that it has left and right sides which are referred to as its borders when viewed from the front. Furthermore, when each of these concepts is clicked, the viewer gets an eight second preview of that aspect from a different dimension. Thus, a click on 'root' will show a transactional view to look down at the vessels of the heart at that level, the same method is applied to the base, which is seen from below at that level, and each of the sides surrounded by lung tissue. Moreover, with experience, the learner is exposed to a variety of views to elicit discriminatory observation; in this case to note the relationship of the lungs to the thorax and the heart between them.

Thus, from such simple elements, the learner is continuously faced with a platform of interrelated detail and imagery to create thought patterns which can deal with a multiplicity of dimension. Figures 30, 31 and 32 demonstrate another technique to deliberately change the image of the heart from a frontal view, as seen in Figure 30, by clicking on the arrow to go to the transthoracic view seen Figure 32. In effect, the learner is asked to review the structure of the anterior view of the heart and its vessels in Figure 30. When ready, the learner will click the forward arrow to go on. Having done so, a field appears
which asks the learner to make a transverse section by clicking on the arrow shown at the left of Figures 30 and 31. The arrow is covered by a transparent button which causes apparent movement of the arrow from left to right, making an apparent transectional swathe through the thorax. In effect, the arrow button shown in Figures 30 and 31, is scripted to take the learner through four more screens at five second intervals, where the arrow is placed in stages from left to right before the screen fades into the transverse view shown in Figure 32. In this way, the learner is encouraged to go back to review the heart and lungs to compare 2-D vertical and transverse sections to create an illusory 3-D perspective.

Figure 32 is designed to present the learner with more information by using the 'About' box. A click on About at the upper right of Figure 32 initiates the appearance of a scrolling field containing considerable information about this aspect of the thorax and its mediastinal contents. Figure 33 shows the scrolling field to reveal more information about the heart by clicking the About box. To maintain the logic of presentation, the click on About, not only shows the scrolling field shown in Figure 33, but its transparent button is also scripted to change to Quit About, when another field appears to cause the learner to click into the posterior mediastinum, as seen in Figure 34. In this instance, when a correct click is made in Figure 34, the learner is taken to a left lateral view of an X-Ray of the chest (Figure 35) which shows the relationship of the heart, bronchial tree, and diaphragm from that side. In the same way, activation of the forward arrow in Figure 35 would raise a challenging question to enable the learner to proceed.
Access to study ICALPs related to neuroanatomy may be gained at undergraduate (Figure 19), or postgraduate (Figures 41 and 42) levels. Thus, undergraduate entry to neuroanatomy 251/4+ is gained via Figure 19, to go to the ICALP shown in Figure 69, which would also be a primary revision module at the postgraduate level. These examples demonstrate the developmental progression from a cluster of plain-learning cards to those which become more complex to vary the level of interest as well as interactively present information to challenge a variety of learners. Figure 70 represents a side view of the brainstem with a thick horizontal line drawn through the midbrain, between the colliculi. The learner is stimulated to do a MouseDown to observe and compare this vertical section with a composite transverse section to develop a 3-D concept in the learner. A click on the forward arrow in Figure 70 is included to direct a question to reinforce the 3-D concept by projecting the learner to the horizontal section shown in Figure 71. After pursuing the information available in Figure 71, a challenging question is issued to reinforce these ideas.

The complexity of this neuroanatomy ICALP begins to show itself even more so in Figure 72 by its view of the diencephalon and medial aspect of the right cerebral hemisphere. Apart from the regular instruments available from a plain-learning screen, Figure 72 shows a boxed ? icon in the upper left hand corner. When clicked by the tip of the browsing tool, the boxed ? icon projects the learner to the problematic question shown in Figure 73. Figure 73 shows a screen containing four fields and a go back arrow. The field at the top left declares the intent of the question; the field to its right contains a specific question related to Figure 72; the intermediate field to the left gives the learner an opportunity to type a response to the question in the scrolling field
below it. If the learner is in any doubt, the go back option will initiate a return to the original screen to obtain more clarification without penalty. The scrolling field in Figure 74 is scripted to accept a solution provided it complies with the demands of the question. Once an answer has been typed and registered in an external file for later scrutiny, a mouse click on the solution box in Figure 74 initiates the appearance of the field shown in Figure 75, which invites the learner to click on it compare individual efforts with the staff solution shown in Figure 76.

3.30 Animated complex-learning cards
A progression of learning from plain and complex-learning cards to a situation which includes a simulated animation sequence may be typified by review of Figures 56 to 59. In this example, the learner has entered the ShArm-ICALP depicted in Figure 51, using the scrolling text window in Figure 55 to go directly to Figure 56. Figure 56 shows a plain-learning card with information designed to establish an important concept of function. The diagram is a simple skeletal view of the posterior aspect of the left shoulder and arm. Figure 57 gives information from the I-I field about the elements of scapular rotation and a click on the forward arrow issues a challenge to click on the ringed axis in Figure 58. The ringed axis already seen, represents the fulcrum of movement of the left scapula during movement. In effect, the ringed axis in Figure 58 incorporates an encrypted transparent button which results in an illusion of animation performed by an intermittent exchange of screens between Figures 58 and 59. This function is repeated several times, which then dissolve into Figure 60. This example may also be observed as an interaction to show reflex action between Figures 23 and 24.
3.31 Summary-score card

The last card in an ICALP provides a performance feedback summary to the learner. It incorporates performance variables which include the time taken and an overall score expressed as a percentage. This technique also provides a valuable tool for the investigation of the mechanisms of learning using ICALP. Using this data, direct comparisons of individual learning strategies and levels of interaction between test and practice situations can be studied. These learning strategies and rates of interaction may be derived for each individual or as a group. Examples of these parameters are collectively shown in Figures 12, 50, 77, and 86.

Using Figure 77 as an example for a fictitious student named J.N.Other, a standard field is in place at the top of the screen. This field contains words of congratulation to J.N.Other for completion of the task, noting that the information in the ICALP will be the basis for a follow-up test, with a suggestion to return to it for revision at any time in the future. A field at the bottom of the screen notes that the score will be recorded for assessment against the name of J.N.Other to encourage a sense of personal control and entry to further interactivity. Between these two fields, is a display of the results obtained by J.N.Other for this particular activity. This information includes the date, start and finish times expressed in hours and minutes, the total number of mouse clicks used throughout, which are summarised as the number of correct hits and incorrect misses, expressed as a score rate for this activity. At this point it is important to note that on this occasion J.N.Other may have pursued the content of this ICALP assiduously from end to end, or may merely have entered to refresh one particular concept from the scrolling index of Main. On
clicking the OK button, the results of each effort are instantly transformed by external functions to be recorded in the personal file of J.N.Other for future reference, as in Figure 12.

3.32 Instant reinforcement

After review of the previous sections, it becomes clear that J.N.Other is able to receive positive reinforcement at each step of the way. Positive responses are delivered from each click of the learning process via Figures 57, 60 and 61, followed by a challenging question which is instantly rewarded by success, or encirclement by flashing hand arrows to show the correct answer, as shown in Figures 65 and 83. Moreover, these results are instantly available at the end of each session (Figure 77) to be stored in a personal accumulating summary file for later review by the results browser in Figure 12.

Figure 25. Regional entry to the ICALP for knee and leg.
Figure 26. Invitation to a second year to enter ICALPs related to the heart.

Cardio
an ICALP of the structure & location of the heart

by
Harry B. Lee
Curtin University
February, 1992

Figure 27. Entry to an early ICALP related to the heart.
Figure 28. The menu of concepts available in the cardio ICALP.

Figure 29. A window of opportunities to evaluate conventional terminology and relationships of the heart.
Figure 30. Conjecture about the heart and its relationships.

Figure 31. Option to view the heart in a transverse dimension.
Figure 32. A challenge to view and compare vertical and transverse aspects.

Now observe the detail of this transverse section of the Thorax.
Note that it is through the mid part of the heart and that you are looking into both of the ventricles and atria.
Also note the arrangement of the THREE LAYERS of the pericardium.

Figure 33. A small scrolling window to gain more information.
Figure 34. A challenging question to reinforce a concept.

This is a left lateral X-Ray of the heart and lungs. The subject is in a sitting position with the shadow of the heart directed forwards and downwards. Compare the location of the root of the heart with the diaphragm below.

Figure 35. A clinical view to initiate the ability to read and interpret an X-Ray.
### Figure 36. A revision menu to reinforce principle concepts.

- **Click on:** Lungs

### Figure 37. Invitation to a second year to enter ICALPs of the lungs.
Figure 38. Male and female subjects to designate entry to endocrine pathology.

Figure 39. Screen of options open to a third year learner.
Figure 40. Learning opportunities open to a postgraduate ergonomics student.

Figure 41. Generic options in postgraduate neurology.
Figure 42. Opportunities for postgraduate neurology.

Figure 43. Generic opportunities for a postgraduate Sports Therapist.
Figure 44. A window of ICALP opportunities in postgraduate Women's Health.

Figure 45. Correlation of names with passwords on a hidden screen.
Figure 46. Passwords programmed into hidden scrolling screens via SOCCER.

<table>
<thead>
<tr>
<th>Names</th>
<th>Passwords</th>
</tr>
</thead>
<tbody>
<tr>
<td>BATEMAN</td>
<td>bingle</td>
</tr>
<tr>
<td>BEAUMONT</td>
<td>entry</td>
</tr>
<tr>
<td>BEECK</td>
<td>house</td>
</tr>
<tr>
<td>BLAZEY</td>
<td>pandora</td>
</tr>
<tr>
<td>BOETTCHER-HU</td>
<td>beast</td>
</tr>
<tr>
<td>BRACKS Adam</td>
<td>angio</td>
</tr>
<tr>
<td>BRADLY Simone</td>
<td>short</td>
</tr>
<tr>
<td>BRAIN</td>
<td>luxury</td>
</tr>
<tr>
<td>BROOKER</td>
<td>loose</td>
</tr>
<tr>
<td>BULICH</td>
<td>wake</td>
</tr>
<tr>
<td>BURNETT</td>
<td>tractor</td>
</tr>
<tr>
<td>BUSCH</td>
<td>hernia</td>
</tr>
<tr>
<td>BUTLER</td>
<td>ninny</td>
</tr>
<tr>
<td>BYRNE</td>
<td>echo</td>
</tr>
<tr>
<td>CACHO</td>
<td>auger</td>
</tr>
<tr>
<td>CHESSON</td>
<td>cardio</td>
</tr>
</tbody>
</table>

Figure 47. Passwords linked to hidden scrolling screens in SOCCER.
Figure 48. An appearance of computer test 1 for a limited period.

This test is in two parts:

It is designed to assess your learning from the Nerve and Reflex Lectures and ICALP's.

Conditions of entry:

One attempt only is allowed in any period of 24 hours. The first attempt will be used for this evaluation. An aggregate of the first and last attempts may be used later.

Figure 49. Conditions of entry to a prescribed computer test.
Figure 50. In this case a learner wishes to review personal effort.

Figure 51. Entry to the shoulder and arm ICALP after selection from Figure 15.
This is a learning package designed to review the anatomy of the shoulder, shoulder girdle and upper arm.

Figure 52. Confirmation of entry to the shoulder arm ICALP.

References used for this ICALP


Besmijian, J.Y. Primary Anatomy, 1982. 8th Edn. Williams & Wilkins.


Figure 53. Scrolling references used to construct the ICALP.
Figure 54. The standardized help menu used in each ICALP.

Figure 55. A scrolling text field to enter a main concept, or review it.
Functionally, the shoulder girdle consists of the structures which form the thoracic inlet, namely both clavicles and scapulae.

Do a mousedown to see a similar picture with the muscles in place.

Then consider how many muscles are attached to the shoulder girdle, and how it can be moved by them.

From this it may be seen that the scapula is a moveable platform which is pulled around by the muscles attached to it.

It can be elevated, depressed, protracted, retracted, rotated and circumducted.

These movements enhance the whole movement repertoire of the upper extremity.

Figure 57. The learner has clicked the I-I to gain further information.
Figure 58. The learner has clicked the forward arrow to raise a question.

Figure 59. An illusion of movement created between screens.
Figure 60. A view of eight concepts, separately, or collectively.

This sagittal cross-section through the shoulder joint shows its intra and extra articular structures.

Do a MouseDown to relate the joint to the surface.

Be able to palpate and locate the various structures, as well as to be able to visualise the deeper (impalpable) structures which you know are there.

To do this, you will learn to manipulate the arm as a lever, rotating it, moving it in various ways with one hand, whilst feeling the results of those movements by placing the other hand over the surface of the shoulder.

Figure 61. The I-I triggered from Figure 60 to elicit further learning.
Figure 62. A click on the forward arrow to initiate a problem.

Figure 63. The right axilla surrounded by an inescapable problem.
Figure 64. A precise answer required about a particular nerve supply.

Figure 65. After three errors the solution is outlined by hand arrows.
Figure 66. A correlation of structures with their function.

Each of the nerves shown here are vulnerable to injury and may require your investigation.

Therefore it is important that you practice finding them on a living person.

You will be asked to do this in practical classes to prepare you for later clinical experience.

From this you can see that the accuracy and quality of the reports and findings made by you may influence those taken by a physician or surgeon to determine the outcome for the patient.

Figure 67. The I-I establishes a professional need to know about structures and functions.
Figure 68. A challenging question about Figures 66 & 67.

Figure 69. Entry to a neuroanatomy ICALP.
Figure 70. MouseDown 3-D integration.

Figure 71. A transverse section to contrast the long axis shown in Figure 70.
The limbic system: medial right cerebral hemisphere
Identify features A - J

Figure 72. Entry to a challenging question (?) about this screen.

The Question is: What nucleus lies deep to the uncus?

Type your answer below

Figure 73. A question raised about Figure 72.
The Question is: What nucleus lies deep to the uncus?

Type your answer below  Click here for the staff solution

The amygdala ...

Figure 74. An invitation to respond to the question in Figure 72.

The Question is: What nucleus lies deep to the uncus?

Type your answer below  Click here for the staff solution

The amygdala ...

Figure 75. After completion, the learner can now view the staff solution.
The Question is: What nucleus lies deep to the uncus?

Type your answer below  

The amygdala ...

Click here for the staff solution

The amygdaloid nucleus or amygdala.

The uncus is part of the limbic system

Figure 76. Comparison of the student response with the staff solution.

Well done. You have covered a lot of ground. You are reminded that the information included in this ICALP is the basis for its follow-up test, and that you are free to come back for further revision at any time you wish to do so.

Name: J.N. Other
Date: Wednesday, 15 February 1995
Start time: 11:44 AM
Finish time: 12:36 PM
Total mouse clicks: 80
Correct (Hits): 68
Incorrect (Misses): 12
Score (Hit Rate): 85%

This score will be recorded against your name for assessment.

Click on OK to go back to SOCCER

Thank you.

OK

Figure 77. A summary to show the achievement J.N.Other.
3.33 Conversion of ICALPs into test items
ICALP modules can readily be changed into test items by conversion of text and diagrams into strings of screens and questions, each scored by a click on a prescribed target. An example of this is given in Figure 48, where entry to CompTest-1 was scripted to show itself on the second year menu on a particular day at a particular time. Moreover, this facility was scripted for extinction at a previously announced time. A click on CompTest-1 in Figure 48 is used to show the conditions of entry to the computer test shown in Figure 49.

3.34 Progression to test items
Although formal test procedures were closely supervised with strict limitations of option, learners were encouraged to improve their score by controlled informal attempts. Thus, to avoid the risk of cramming and use of rote learning, only one attempt was permitted within any period of 24 hours. In this way, CompTest items were applied under controlled conditions as pre and posttests, with further opportunities of improvement at specific periods. These conditions of entry are shown in Figure 49, after which the learner may wish to use the examination results summary in Figure 50 to compare and evaluate these efforts by review of the cumulative data recorded in Figure 12.

As a further example of this progression, the screen used to apply the conditions of entry to CompTest(2) in Figure 49 was readily modified by a single button to facilitate entry to the cerebellar test shown in Figure 78. Thus, a click on Cerebellar Test in Figure 78 moved the learner to the introductory screen of the cerebellar test shown in Figure 79. The first screen of the cerebellum test is a mere
modification of its ICALP counterpart, with similar events programmed thereafter.

The screen shown in Figure 80 serves as a reminder to the candidate about the cerebellar test being a follow-up to the ICALPs for cerebellar structure, function and dysfunction. Furthermore, the candidate is advised how to obtain the best possible results and that the results will be stored for future evaluation in the subject. Although progress may be made from Figure 80 to 81 without penalty, the candidate is reminded that this is the last opportunity to quit until the test is finished. Because the target buttons of all test items are arranged in a precise manner, Figure 81 serves as a reminder to use the tip of the browsing tool to identify the target, which will change into a watch if clicked correctly. The candidate is also advised not to click indiscriminately because only three clicks are allowed to find the target on each screen. Figure 82 gives a clear example of the question on card number 25 out of a total of 50. The boxed field at the top left of the picture is used to give the candidate continual information about progression through the test. The simple question shown in the boxed field at the bottom right of the picture in Figure 82 is designed to evaluate correct anatomical orientation. Such questions require the candidate to define left from right from upper or lower aspects.

As shown by Figure 83, the candidate was unable to identify the target after three clicks, causing the appearance of flashing hand arrows to identify the target. In this way, a mechanism of instant positive reinforcement can be engendered, not only to inform the candidate that an error has been made, but to also identify the correct location by a precise click on the target to go to the next question.
Figure 84 shows that the candidate has arrived at question 43 out of 50, and is now faced with a more complex style situation. Firstly the question asks the candidate to decide if the diagram represents a terminal knob of a mossy fibre, or conversely if it is a glomerular synapse. A response to either challenge requires the candidate to click on two disparate anatomical features. In this case, the correct solution is related to the question contained in the boxed field at the top right hand side of the screen. Mainly to illustrate the mechanism of instant positive reinforcement, the candidate was depicted as one unable to unravel the solution to the question in Figure 84. The desired target response shows the rosette outlined by flashing hand arrows in Figure 85, with the browsing tool over the rosette for a click to go on. However, despite the previous errors shown in Figures 83 and 84, Figure 86 shows that J.N.Other has achieved a satisfactory score rate of 83.9% for this cerebellar test. At some stage in the future, J.N.Other will be able to improve this result by activation of the revisit opportunities discussed with reference to Figure 78.

Figure 87 is presented as a further example of a computer test, in this case as a follow-up to the NerveICALP+. Observation of Figure 88 shows that there are 91 test cards in the nerve test, and that this is card 72. In this case, a functional, or physiological question is posed, which requires a structural, or anatomical response. The tip of the browsing tool is aimed at the correct target to enable the candidate to proceed without penalty. Figure 89 shows the candidate at card 52, now faced with a controversial functional question about nerve endings. In effect, Figure 89 represents a true-false question presented in a visual mode with anatomical options.
Conversely, Figure 90 represents a complex question about two physiological concepts which link two anatomical options related to the innervation of a muscle spindle and its associated skeletal muscle fibre(s). The solution to the question is shown by the browsing tool on the extrafusil (muscle) fibre.

This test is in **two parts**

The regular Comp test is to assess your learning in relation to structure, function and dysfunction in the neck, trunk & limbs.

MCQTI is a collection of multiple choice questions in pathology.

**Conditions of entry**

One attempt only is allowed in any period of 24 hours

The first attempt will be used for this evaluation

An aggregate of the first and last attempts will be used later.

To Cerebellar Test

Figure 78. The conditions of entry to a two-part computer test.
Figure 79. Entry to a cerebellum test.

This is a follow-up test of the ICALP's for cerebellar structure, function & dysfunction.

- To gain the maximum possible points, identify and click on each target.
- Each time you click on the wrong area, you will build up a negative score.
- The results will be stored in a file and will be used as part of your assessment in this subject.
- After this screen you will not be able to quit until finished!

Figure 80. Reminder about the conditions of entry to the test.
IMPORTANT NOTE

Use the TIP of the FINGER of the browsing tool to identify the target.

CLICK ONCE ONLY, THEN WAIT FOR THE BROWSING TOOL TO CHANGE TO A WATCH

IF YOU ARE TOO FAST, YOU WILL BLOW AWAY YOUR SCORE!

If there is no change after THREE CLICKS, indicators will show the target, then click on it to go on.

Figure 81. An injunction of precision to achieve a high score.

Figure 82. A question to evaluate orientation of the cerebellum.
Figure 83. Recognition of left from right when viewed from below.

Figure 84. A complex question to locate one of several options.
If you believe this diagram shows the terminal knob of a mossy fibre, click on the rosette

Instead, if you think it is a view of a glomerular synapse in the purkinje layer, then click on the axon

Figure 85. Clarification is given by hand arrows.

Hopefully you feel that you have done well with the this test.
Your score so far is shown below.

<table>
<thead>
<tr>
<th>J.N. Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
</tr>
<tr>
<td>Date:</td>
</tr>
<tr>
<td>Friday, 17</td>
</tr>
<tr>
<td>February 1995</td>
</tr>
<tr>
<td>Start time:</td>
</tr>
<tr>
<td>4:31 PM</td>
</tr>
<tr>
<td>Finish time:</td>
</tr>
<tr>
<td>5:15 PM</td>
</tr>
<tr>
<td>Total mouse clicks:</td>
</tr>
<tr>
<td>56</td>
</tr>
<tr>
<td>Correct (Hits):</td>
</tr>
<tr>
<td>47</td>
</tr>
<tr>
<td>Incorrect (Misses):</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>Score (Hit Rate):</td>
</tr>
<tr>
<td>83.9%</td>
</tr>
</tbody>
</table>

When you are ready, click 'OK' to go to the start screen.

Figure 86. Nevertheless, despite the errors in Figures 83 & 84, J.N.Other achieved a score of 83.9% for this test.
NerveTest+
A follow-up test to the Nerve ICALP+

by
Harry B. Lee
Curtin University
October, 1992

Quit Test Click here to

Figure 87. Entry from SOCCER to the NerveTest+.

Card 72 out of 91

If you think this neuron is 'polarized' click on its cell body.
If you think it is 'depolarized' then click on a Schwann cell.

Figure 88. A functional question requiring a structural response.
If you believe that 'nerve endings' are actually receptor sites, click on the receptor filaments.

If you think otherwise, then click on the dendrite.

Figure 89. A functional question with two anatomical sites of response.

If you believe that the rate of conduction along a Golgi Type I fibre is the same as that of an A alpha fibre, click on the extrafusal fibre.

If you disagree, then click on the equator of the bag fibre.

Figure 90. Two physiological concepts linked with two anatomical options.
3.35 A multiple choice question format

Multiple choice question test items (MCQTI) were created, not only as a method to verify the depth of understanding achieved by ICALP learning, but also to compare their cost-benefits with traditional methods of evaluation. Figure 91 shows a screen of entry to MCQTI-1, which was developed to rate learner competence in up to ten different areas of anatomy. In this style, ten areas of anatomy were identified for evaluation by random groupings of ten questions. On face value, the MCQTI package may appear to be a simplistic enterprise, but it contains devices which render it invaluable as a flexible instrument of measurement. In essence, Figure 91 demonstrates the face of this flexibility, whereby its list of ten topics is sequentially typed into the transparent field above the browsing tool. As each topic is typed in, the HyperCard® Stack Script is programmed to fit the logic of the remaining sequences. This process is illustrated during the development of a Comp-E-Track adaptation from an MCQTI format, as seen in Figures 101 to 104.

Although multiple choice questions may be constructed to respond to more than one answer, Figure 92 illustrates a MCQTI which declares that only one correct solution is expected on this occasion. The centre field of Figure 92 is designed to clarify the conditions of the test, with one point being gained for a correct answer, and one lost for an incorrect answer. In this case, the candidate is advised that only one solution is to be selected as an answer to each question, but that such responses can be changed at anytime throughout the test. Other options are revealed in the description of Figures 101 to 104 below.
In Figure 93, the candidate has reached question 12 out of the 100 contained in the MCQTI. In review, item 12 is a normal multiple choice question requiring the identification of one answer allied to four closely related distracters. Figure 94 shows that the candidate has selected number 2 as the best option at this stage, but is free to alter the selection at any time during the test. Question number 88 outlined in Figure 95, is a complex, problem-based question about Mary Standfast, who exhibits abnormal reflexes and a wide style of gait presented as signs, together with a glove and stocking impairment and paraesthesia to represent symptoms. From this information, the candidate has responded by the selection of number 5 as the solution. At the end of the MCQTI, the screen shown in Figure 96 is reached, which gives the candidate an option to re-check the answers already given, or finish the test. The response in Figure 96 suggest that the candidate wishes to go back to review and modify selections before clicking to finish the test.

Eventually, after a click on 'finish' in Figure 96, the candidate is transported to the view shown in Figure 97. The information available to J.N.Other in Figure 97 is constructed to give a comprehensive review of the total score and distribution of marks recorded for later comparison, as previously described in Figure 12. From these results, J.N.Other is able to obtain an instant review of achievement in the ten designated areas, with options to compare previous selections with staff solutions by a click on 'see answers', or gain further advice by a click on 'see ratings'. At this juncture, J.N.Other has chosen to click the 'see answers' option in Figure 97, which enables a quick review of selections made for comparison with the staff solutions. This option not only gives further reinforcement, but also enables J.N.Other to select the correct solution at a future attempt. This mechanism is illustrated
by Figure 98, to show that the unalterable selection made by J.N.Other coincides with the staff solution indicated by a flashing hand arrow.

3.36 Expanded ratings

Alternatively, J.N.Other may wish to review the 'see ratings' option in Figure 97. A click on 'see ratings' immediately shows a field containing the ratings scale to demonstrate the normal distribution of ratings with percentages achieved. Thus, a rating of A+ would equate with a percentile score of 85-100, whereas a rating of F would represent an achievement of less than 39%. Should J.N.Other wish to pursue the matter further, the 'expand ratings' option may be selected by clicking it. Having selected to expand the ratings in Figure 99, J.N.Other gains the benefit of a selection of remarks to coincide with each of the ten ratings achieved, as shown in the scrolling field in Figure 100. In this example, the candidate is congratulated for an exceptional level of knowledge in autonomic anatomy with a recommendation to give full attention to other topics. The level of success achieved in cardiology is quite satisfactory, with encouragement to review it on a regular basis. In the same vein, the success rate for the central nervous system suggests that its result is more than adequate, but that there is a need to keep up to date to avoid slipping behind. A word of caution is issued for haematology, the results of which are considered to be distinctly borderline, and those for myology extremely weak, initiating a request to make an appointment to visit the Subject Controller as soon as possible.
Figure 91. Entry to a MCQTI to rate learner competence in ten different areas of anatomy.

Note: Each question has only ONE correct answer.

- One point is gained for a correct answer and one lost for an incorrect answer.
- Only one answer can be selected for each question. Responses can be changed at anytime during the test.
- At the end of the test, an opportunity is given to "RE-CHECK" selected answers.
- When satisfied at the end of the test, click "FINISH" to view the results table.
- When finished, results are shown as percentages for each of the topics tested.
- At the end of this test, a table shows the ratings scored for each topic, with recommendations for any further action.
- Results will be stored in the learners file as part of the assessment in this subject.
- Once started, it will not be possible to quit until all questions have been attempted.

Figure 92. Advice to the candidate prior to launching the test.
The musculo-cutaneous nerve supplies which of the following?

1. Biceps brachii, brachialis, supinator and an area of skin on the radial side of the forearm
2. Biceps brachii, brachialis, coracobrachialis and an area of skin on the lateral side of the forearm
3. Biceps brachii, brachioradialis, coracobrachialis and an area of skin on the radial side of the arm
4. Biceps femoris, brachialis, coracobrachialis and an area of skin on the radial side of the forearm
5. Biceps brachii, brachialis, coracobrachialis and an area of skin on the radial side of the forearm

Figure 94. Option 2 selected. Options can be changed throughout the test.
Question 88 out of 100

Mary Standfast has no tendon reflexes and a reduced vibration sense in the extremities with a 'glove-and-stocking' impairment. MS also has paraesthesia and a 'burning sensation' in the soles of her feet, with a 'wide style of gait'. Which of the following is most likely?

1. Diabets insipidus
2. Diabets mellitis
3. Diabetic neuropathy
4. Autonomic neuropathy
5. 2, 3, & 4 above

Figure 95. A problem-based MCQ responded to by a click on 5.

MCQTI

To review and modify selections, click on RE-CHECK ANSWERS.

When satisfied with selections, click on FINISH.

Figure 96. An option to re-check answers and alter selections.
### Table

<table>
<thead>
<tr>
<th>Topics</th>
<th>Total Questions</th>
<th>Total Answers</th>
<th>Incorrect Answers</th>
<th>Score</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomic N.S.</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>80%</td>
<td>A</td>
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<tr>
<td>Cardiology</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>100%</td>
<td>A+</td>
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<td>Central N.S.</td>
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<td>6</td>
<td>4</td>
<td>60%</td>
<td>B-</td>
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<td>Haematology</td>
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<td>9</td>
<td>1</td>
<td>90%</td>
<td>A+</td>
</tr>
<tr>
<td>Myology</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>100%</td>
<td>A+</td>
</tr>
<tr>
<td>Osteology</td>
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<td>8</td>
<td>2</td>
<td>80%</td>
<td>A</td>
</tr>
<tr>
<td>Pathology</td>
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<td>7</td>
<td>3</td>
<td>70%</td>
<td>B+</td>
</tr>
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<td>10</td>
<td>0</td>
<td>100%</td>
<td>A+</td>
</tr>
<tr>
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<td>10</td>
<td>9</td>
<td>1</td>
<td>90%</td>
<td>A+</td>
</tr>
<tr>
<td>Syndesmology</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>90%</td>
<td>A</td>
</tr>
<tr>
<td><strong>OVERALL</strong></td>
<td><strong>100</strong></td>
<td><strong>85</strong></td>
<td><strong>15</strong></td>
<td><strong>85%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Figure 97. A view of marks recorded for the test.

### Question 12 out of 100

The musculo-cutaneous nerve supplies which of the following?

1. Biceps brachii, brachialis, supinator and an area of skin on the radial side of the forearm

2. Biceps brachii, brachialis, coracobrachialis and an area of skin on the lateral side of the forearm

3. Biceps brachii, brachioradialis, coracobrachialis and an area of skin on the lateral side of the arm

4. Biceps femoris, brachialis, coracobrachialis and an area of skin on the radial side of the forearm

5. Biceps brachii, brachialis, coracobrachialis and an area of skin on the medial side of the forearm

Figure 98. A comparison of selected answers with staff solutions.
Figure 99. The ratings scale, which may be expanded or hidden.

<table>
<thead>
<tr>
<th>Topic</th>
<th>A+</th>
<th>A</th>
<th>B-</th>
<th>B+</th>
<th>B-</th>
<th>C+</th>
<th>C</th>
<th>D+</th>
<th>D</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomic</td>
<td>85-100</td>
<td>80-84</td>
<td>75-79</td>
<td>70-74</td>
<td>65-69</td>
<td>60-64</td>
<td>55-59</td>
<td>45-49</td>
<td>40-44</td>
<td>00-39</td>
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<tr>
<td>Cardiology</td>
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<td>Central N.S.</td>
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<td>Osteology</td>
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<tr>
<td>Pathology</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVERALL</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click Hide Ratings to remove the rating scale
Click Expand Ratings for more information

Congratulations, your level of knowledge of the ANS is exceptional and it is recommended that you give your full attention to other topics.

Your level of success in Cardiology is highly satisfactory, but you are encouraged to actively review it on a regular basis.

Your rate of success for the Central NS is above average, however, if you don’t keep up to date on a regular basis you may slip behind.

The results of your efforts in this test for Haematology are distinctly borderline. You are in jeopardy unless you take rigorous action to rectify the situation.

From the results of this test, your standing in Myology is extremely weak. You are requested to make an appointment to visit the Subject Controller as soon as possible.

Figure 100. A report to the candidate at the end of the test. Compare with Figures 97 & 99 and Table 1.
The comments shown in Figure 100 are programmed to reflect the content of the items listed in Table 1. Unknown to the candidate, automatic selection of comments outlined in Table 1 are scripted to correlate individual scores achieved with the ten topics, using eleven ratings ranging from A+ to F. These comments are carefully worded to give appropriate guidance to learners in each category.
Table 1. Review of statements programmed into an MCQTI which are automatically correlated with the score achieved.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>Congratulations, your success in 'topic name' is exceptional. We recommend that you give full attention to other topics.</td>
</tr>
<tr>
<td>A</td>
<td>Well done, your achievement in 'topic name' is very strong and advise that you review this area from time to time.</td>
</tr>
<tr>
<td>A-</td>
<td>Your rate of success in 'topic name' is well above average and suggest that you up-date this subject by steady revision.</td>
</tr>
<tr>
<td>B+</td>
<td>Your level of success in 'topic name' is quite satisfactory, but you are encouraged to actively review it on a regular basis.</td>
</tr>
<tr>
<td>B</td>
<td>Your rate of achievement for 'topic name' in this test is above average, but you are advised to revisit its concepts in detail quite frequently.</td>
</tr>
<tr>
<td>B-</td>
<td>Your rated level of success in 'topic name' is more than adequate, however, if you don't keep up to date on a regular basis you may slip behind.</td>
</tr>
<tr>
<td>C+</td>
<td>Your level of success in 'topic name' can only be rated as adequate at present. It is recommended that you make a serious attempt to improve your standing as soon as possible.</td>
</tr>
<tr>
<td>C</td>
<td>The results of your efforts in this test for 'topic name' are distinctly borderline. You are in jeopardy unless you take rigorous action to rectify the situation.</td>
</tr>
<tr>
<td>D+</td>
<td>Your present position in 'topic name' is distinctly weak. You are advised to seek the help of a Resource Person as soon as possible.</td>
</tr>
<tr>
<td>D</td>
<td>From the results of this test, your standing in 'topic name' is extremely weak. You are requested to make an appointment to visit the Subject Controller as soon as possible.</td>
</tr>
<tr>
<td>F</td>
<td>The results of this test in 'topic name' suggest that you are in serious trouble in that subject and are strongly advised to seek immediate help from the academic staff, and consider consultation with the Counselling Services at this University.</td>
</tr>
</tbody>
</table>
3.37 Comp-E-Track test items

Pre and posttest items provide learners and administrators with data from the point of entry to later progression. Using the techniques already described, levels of concentration and success can be continuously tracked and recorded for mutual review by learners and administrators. The MCQTI devices already described and represented in Figures 91 to 100, can be extended into a computerized evaluation and tracking system, known as Comp-E-Track.

The basic elements of a MCQTI are incorporated into a Comp-E-Track instrument, with further built-in labour saving devices. Figure 101 represents the same screen already presented for the MCQTI shown in Figure 91. However, in the case of a Comp-E-Track device, the content is presented on separate question cards which are continuously sorted in random fashion to minimise the risk of learners constructing a grid to predicate a later outcome.

Figures 102 to 104 demonstrate a Comp-E-Track-Shell in preparation. As already mentioned for an MCQTI, the first screen of a Comp-E-Track includes a field of objects which, once entered, become part of the stack script for further development. This facility is shown in Figure 103, where a scrolling field is used at the top right of the screen to set the title of the topic for this particular card as neuropathology. The root of a neuropathological question can then be typed into a blank field already inserted, with five responses alongside the 'hot' button numbers below. At this point, the developer can select the correct answer from the box at the centre of the screen, placing a flashing hand arrow against that number, in this case, alongside number 2. Figure 104 illustrates the question as it would be seen by the candidate, where
the two selection boxes from the developmental stage are rendered invisible. Using this method, each of the 100 screens available throughout a Comp-E-Track-Shell can be set to show previously validated questions in a randomly sorted format which do not appear in the same sequence thereafter. Furthermore, at the end of any learning or test period, the learner is provided with mechanisms of instant reinforcement, with an option for later evaluation of the results outlined in Figure 105.

Figure 101. Comp-E-Track, an MCQTI adaptation.
Comp-E-Track-3
A computerized MCQ test to evaluate learner competence in the:


by
Harry Lee
Curtin University,
October, 1993

Quit Comp-E-Track  CLICK HERE TO START

Figure 102. A Comp-E-Track shell in preparation.

Question 15 of 100  Correct Answer 2  Topic Neuropathology

The Glabella reflex is activated over the?

1 Olecranon
2 Frontal bone
3 Tibial tuberosity
4 Tendo calcaneum
5 Tendon of biceps brachii

Figure 103. A Comp-E-Track question during its development.
The Glabella reflex is activated over the?

1. Olecranon
2. Frontal bone
3. Tibial tuberosity
4. Tendo calcaneum
5. Tendon of biceps brachii

Figure 104. A Comp-E-Track question as seen by the candidate.

Previous Results Browser
Use the scroll bar on the right to review your results

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<thead>
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<th>Date</th>
<th>Time (min)</th>
<th>CALP/Test Title</th>
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<th>Clicks ✓</th>
<th>Not</th>
<th>Att. Alt. Cards</th>
<th>Score</th>
<th>Rating</th>
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<td>Nerve/ICALP+</td>
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<td></td>
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<td></td>
<td>D</td>
<td>128</td>
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<tr>
<td>5/8/98</td>
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<td>Nerve/ICALP+</td>
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<td></td>
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<td>19</td>
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<td>119</td>
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<td>65</td>
<td>12</td>
<td></td>
<td>D</td>
<td>119</td>
<td>81.5%</td>
</tr>
<tr>
<td>5/8/98</td>
<td>12</td>
<td>NeuroAdBrainStu</td>
<td></td>
<td></td>
<td>59</td>
<td>11</td>
<td></td>
<td>D</td>
<td>18</td>
<td>81.4%</td>
</tr>
<tr>
<td>5/8/98</td>
<td>55</td>
<td>CarpalNarStruct</td>
<td></td>
<td></td>
<td>160</td>
<td>21</td>
<td></td>
<td>D</td>
<td>59</td>
<td>96.9%</td>
</tr>
<tr>
<td>6/9/98</td>
<td>140</td>
<td>Nerve/ICALP+</td>
<td></td>
<td></td>
<td>158</td>
<td>10</td>
<td></td>
<td>D</td>
<td>139</td>
<td>86.4%</td>
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<td></td>
<td></td>
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<td>0</td>
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<td>D</td>
<td>119</td>
<td>100.0%</td>
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<tr>
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<td>48</td>
<td>Reflex/ICALP</td>
<td></td>
<td></td>
<td>58</td>
<td>13</td>
<td></td>
<td>D</td>
<td>119</td>
<td>77.6%</td>
</tr>
<tr>
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<td>23</td>
<td>Nerve/ICALP+</td>
<td></td>
<td></td>
<td>23</td>
<td>1</td>
<td></td>
<td>D</td>
<td>129</td>
<td>95.6%</td>
</tr>
<tr>
<td>11/8/93</td>
<td>20</td>
<td>Nerve/ICALP+</td>
<td></td>
<td></td>
<td>40</td>
<td>1</td>
<td></td>
<td>D</td>
<td>129</td>
<td>97.5%</td>
</tr>
<tr>
<td>12/8/93</td>
<td>62</td>
<td>Nerve/ICALP+</td>
<td></td>
<td></td>
<td>100</td>
<td>1</td>
<td></td>
<td>D</td>
<td>129</td>
<td>99.9%</td>
</tr>
<tr>
<td>13/8/93</td>
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<td>Nerve/ReflexTest</td>
<td></td>
<td></td>
<td>170</td>
<td>43</td>
<td></td>
<td>D</td>
<td>129</td>
<td>71.2%</td>
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<td></td>
<td>100</td>
<td>74 26 0</td>
<td></td>
<td>D</td>
<td>129</td>
<td>98.9%</td>
</tr>
<tr>
<td>13/8/93</td>
<td>30</td>
<td>Nerve/ICALP+</td>
<td></td>
<td></td>
<td>154</td>
<td>51</td>
<td></td>
<td>D</td>
<td>155</td>
<td>98.3%</td>
</tr>
<tr>
<td>16/8/93</td>
<td>28</td>
<td>Nerve/ICALP+</td>
<td></td>
<td></td>
<td>99</td>
<td>5</td>
<td></td>
<td>D</td>
<td>129</td>
<td>94.9%</td>
</tr>
<tr>
<td>16/8/93</td>
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<td>Nerve/ICALP+</td>
<td></td>
<td></td>
<td>158</td>
<td>9</td>
<td></td>
<td>D</td>
<td>129</td>
<td>93.4%</td>
</tr>
<tr>
<td>16/8/93</td>
<td>36</td>
<td>SOCCER T/F-2</td>
<td></td>
<td></td>
<td>100</td>
<td>95 5 0</td>
<td></td>
<td>D</td>
<td>129</td>
<td>90.9%</td>
</tr>
</tbody>
</table>

Figure 105. A summary visible to each learner and the Subject Controller.
3.38 True-False test items

True-false test items, or TFTIs, were developed to cause variation of demand as well as provide interest for the learner. Although true-false tests possess certain limitations, they demand absolute accuracy in response to questions. The entrance to a TFTI is shown in Figure 106, which is set to evaluate the quality of learning from the cerebellar ICALPs.

![This True-False-Test has been designed to measure your rate of success when learning from the cerebellar ICALP's](image)

by
Harry B. Lee
Curtin University
September, 1993

Figure 106. Entry to a True False Test Item.

Figure 107 shows a subsequent screen designed to clarify the conditions of entry to the candidate. Apart from a field containing information about the reasons for the test, the middle field advises the candidate how to gain the maximum possible points from the test, and that each box selected will not only turn black, but can also be de-selected by a
further click without penalty. Questions in TFTIs can be undertaken in any order of preference, using the arrows at the bottom of each screen to do so. The candidate is advised to review selections at any time during the test, and that no attempt at a question will build up a negative score. As with MCQTI and Comp-E-Test items, at the end of each TFTI, the candidate is able to make final adjustments, then compare given answers with staff solutions.

This test has been designed to assess the ratio of learning from lectures and ICALP’s related to cerebellar structure, function & dysfunction.

- To gain the maximum possible points, read each question carefully and select a solution by clicking on the true, or false box accordingly.

- Each time you make a selection, the box selected will become black. One further click on that box will de-select it without penalty.

- Questions may be attempted in any order chosen.

- Use the arrows at the bottom of the screen to work backwards and forwards throughout the whole test to enter or modify your selections.

- Use the arrows to review selections at any time during the test. Selections can changed without penalty.

- No attempt at any of the questions will build up a negative score. Therefore, it is advisable to attempt all of the questions.

- Click ‘see answers’ to compare selections with staff solutions at the end of the test.

Figure 107. Advice before entry to a TFTI.

To emphasise the scoring system shown in Figure 108, the candidate is advised how to proceed to gain the best result from the test. To avoid guessing, the method described in Section 2.7 (p 20) was applied (Bindman & Elleway, 1985; Harkin, Dixon, Reid, & Bird, 1986; Lee, 1994; Lee & Kemp, 1994; Pollard & Davenport, 1994; Stewart, 1990) In this way, a correct answer gained one point, no attempt to answer
reduced the accumulated score by one point, and an incorrect answer reduced the running score by two points.

Think very carefully about each selection, because the following scoring system is designed to prevent guessing:

- Correct Answer = plus 1
- No Attempt = minus 1
- Incorrect Answer = minus 2

Choices may be altered at any time between the question screens. When satisfied with the final selections, click the FINISH button on the penultimate screen.

When ready, click the forward arrow to start the test...

Figure 108. Advice about grading methods in a TFTI.

A typical example of the presentation of a group of ten true-false questions is given in Figure 109, where the candidate has already made the selections illustrated by black boxes to the right of the screen. As already mentioned, any initial selection may be de-selected and re-entered by a series of mouse-clicks. As a reminder about the marking scheme, the candidate can use the I-I at the top of the screen to show a field for this purpose without penalty. As before, the candidate can also observe the number of remaining questions by looking at the boxed field at the top left of the screen.
### True and False Questions

<table>
<thead>
<tr>
<th>Number</th>
<th>Statement</th>
<th>T</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>The reticulotegmental nucleus can be located in the pons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Projections into the cerebellum from spinal cord efferents are classified as part of the archicerebellum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>The vestibular nuclei possess five subdivisions on each side of the brainstem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Corticopontine tracts from the cerebral cortex to the ipsilateral pontine nuclei, project to the opposite cerebellar cortex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>The reticulotegmental nucleus can be located in the thalamus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>The 'finger nose' test can be used to test 'past pointing', or dysmetria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Neocerebellar lesions are demonstrated by loss of skilled movements, hypotonus and nystagmus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Inco-ordinate movements may be referred to as 'hypersynergia'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>Vestibulospinal problems may include, asynergia, asthenia, flaccidity, and a staggering gait</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Inco-ordination of movements may be referred to as ataxia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 109. Selections shown as black boxes may be altered at anytime in the test.*

---

### TRUE/FALSE QUESTIONS

Hopefully you have chosen your answers wisely because of the scoring system employed:

- **Correct Answer** = plus 1
- **No Attempt** = minus 1
- **Incorrect Answer** = minus 2

To review and modify selections, click on **RE-CHECK ANSWERS**.

When satisfied, click on **FINISH**.

*Figure 110. Options to re-check answers, or finish the test.*
At the end of a TFTI, as shown in Figure 110, the candidate is again reminded of the marking system, with options to either modify previous selections by a click on 're-check answers', or choose to 'finish' the test. After finishing the test, the candidate is able to revisit selections made for comparison with the staff solutions, each of which are superimposed by a tick, which can be seen in Figure 111.

![Table of True and False Questions](image)

**Figure 111.** Comparison of 'ticked' staff solutions with the candidates ‘black box’ selections made in Figure 109.

### 3.39 Feedback items

To gain insight into learner reaction to strategies used within the CMLE, the feedback items (FBIs) illustrated in Figures 112 to 117 were developed with an inventory of over forty items. The use of an FBI empowers individual learners to, either directly type-in their responses to specific questions, or click onto radio-buttons to register their views. These data are stored via XCMDs and XFCNs in
Microsoft® Excel®, which remain invisible to learners but are filed for later correlation and research. To capture the creativity of any group, a final type-in field is designed to stimulate the learner to identify preferences from the list of those shown in Figure 116.

![Feedback instrument](image)

**FeedBack**

is an instrument designed to measure your reactions to strategies applied whilst learning anatomy

by

Harry B. Lee
Curtin University

Figure 112. Entry to a FeedBack Instrument.

The introductory screen to an FBI is shown by a hand of welcome in Figure 112. Although individual responses to the FBI are registered through SOCCER, the logo is intended to set the scene for full acceptance of any information during the process. Matters raised in an FBI were developed to register hard facts in the first instance, prior to delving into specific detail and freedom of expression. Questions to elicit responses in a factual manner are shown as the second screen of an FBI in Figure 113.
I entered the physiotherapy course at Curtin as:

- High school graduate
- A mature age student
- An overseas student

My TEE aggregate, or Yr 12 equivalent on entry was:

- As a high school graduate: [Type in answers] or... N/A
- As a mature age student: [Type in answers] or... N/A
- As an overseas student: [Type in answers] or... N/A

My TEE results, or equivalent of final year 12 grades were:

- English [Type in answers] % or... N/A
- English Lit. [Type in answers] % or... N/A
- Human Biol. [Type in answers] % or... N/A
- Maths (all kinds) [Type in answers] % or... N/A
- Chemistry [Type in answers] % or... N/A
- Physics [Type in answers] %

Please type in one other subject [Type in answers]

Figure 113. Information about 2-D cognition and transfer into a 3-D skill.

The intent of this particular group of questions is intended to establish parameters for the correlation of 2-D cognition with the acquisition of a 3-D skill. The first three questions serve to categorise the candidate as either a recent high school graduate, a mature aged entrant, or an overseas student. This is followed by opportunities to type in the aggregate of entrance examination requirements. In the same way, type-in boxes were used to elicit scores achieved in English, English literature, Human biology, Mathematics, Chemistry, Physics, and one other subject considered significant to the learner.

The third screen, Figure 114, was designed to gain data to measure a range of attitudes for correlation with learning styles. Apart from the first question, which asked the individual to declare the number of hours per week spent learning anatomy, the remainder are set to elicit
quantitative data registered on a five point Likert-type scale, from low to high.

![Image of a table with Likert-scale options](image-url)

**Figure 114.** Information to correlate attitudes with subsequent results.

Such responses are recorded by clicking radio-buttons displayed in a boxed grid, which can be selected, or de-selected at any time throughout the FBI. In this way, information is gained to measure attitudes towards learning in anatomy, such as motivation, comprehension, perceived achievement, satisfaction with progress, learning by listening, learning from visual images, learning by reading, learning by doing, learning from lectures, and learning from laboratory situations.

The fourth screen of questions shown in Figure 115 was designed to measure learner attitudes of interest, ability, and preference for correlation with learning styles.
Figure 115. Information to correlate attitudes with learning styles.

Thus, these questions reflect interest in learning by computer with, either a desire to learn anatomy from lectures and laboratory periods only, or a combination of lectures and laboratory sessions. Information is elicited to compare the ability to learn anatomy independently with a desire to do so. The desire to learn anatomy followed by lecture-seminars, or informal open laboratory sessions interspersed with open laboratory sessions, challenge tests, and a preference for learning with friends, or independently, can be measured. In the same way, the influence of tests upon learning anatomy and a perceived correlation of marks with effort can also be measured.

Figure 116 shows the fifth screen designed to acquire information from comparative statements typed as single line responses.
In no more than one line, please type in your reactions to:

The thing I value most about anatomy lectures is

The thing I value least about anatomy lectures is

The thing I value most about anatomy laboratory sessions is

The thing I value least about anatomy laboratory sessions is

The thing I value most about learning anatomy by ICALPs is

The thing I value least about learning anatomy by ICALPs is

Figure 116. Strategies to gain information about learning styles.

Hence, a concept 'valued most' about anatomy lectures can be compared with the 'thing valued least' about anatomy lectures. In the same way, things valued most about learning anatomy by laboratory sessions, or from ICALPs, can be assessed against statements to the contrary in these two areas.

The final screen of an FBI, is shown in Figure 117, which not only acknowledges the learner, but also makes an assertion that note will be taken of the comments made. This screen includes an invitation to type in any further suggestions to facilitate unexpected information about learning anatomy at the tertiary level.
Thank you for your hard work in anatomy

Your feedback will be invaluable to help us improve future learning in anatomy and to make the best use of our resources.

We value your efforts and our objectives are to help you develop into an autonomous, professional person, responsible for your own learning for the rest of your life. In this way, you will continue to absorb new information with enough confidence to adapt and apply it to challenging and changing situations.

Please type any other suggestions, ideas or comments in the box below. This information will be treated with the utmost confidence.

Figure 117. Acknowledgment to facilitate unexpected information.

Figure 118. Allocation of a problem from a personalized box to the candidate.
3.40 Problem assignment

In a problem-based environment, SOCCER is used to provide randomised groups of problems to challenge its users. By a click on the problem assignment box in Figure 118, each learner can be allocated a particular problem which can be viewed on the screen at a workstation and printed in the CMLE.

![Random Coding of Problems](image)

**Figure 119.** Random coding of problems which remain invisible to the learner.

The random method of distribution of problems to learners is vested with the Stack Script of SOCCER in the screen shown in Figure 119. Using this technique, all names of a cohort are entered into the scrolling field by the Subject Controller, with randomized key titles placed alongside each name. Although the list shown in Figure 119 may remain hidden to each individual learner, its distribution can be
programmed for sequential presentation to the student in a dialogue box at seven designated intervals.

3.4.1 Problem examples
Each problem is constructed to present an open ended case study to reinforce previous learning to induce additional research in support of an appropriate solution. Resource Persons are made available for consultation during laboratory sessions, after which solutions are submitted in a specified time frame. Learners are encouraged to work as individuals, or in small groups, with a limit of four members to a group. Individuals, or groups, are assessed by interaction with Resource Persons, with an objective grade from the Subject Controller. To engage the imagination of participants, situations are created in clusters of four problems. The following examples show how problems were randomly distributed to stimulate problem-based learning via SOCCER.
Bart Bludnock is a 49 year old toxicologist. BB has been treated by a naturopath for the last two years for 'weakness in the legs' and nocturnal 'restless leg syndrome', whatever that means. BB was recommended high doses of calcium and cyanocobalamin but now seems to be getting worse.

Previous clinical history:

BB has been referred to you, complaining of trembling and weakness in the muscles of his lower extremities, as well as a feeling of ants crawling over his extremities. You may have already reached an intuitive diagnosis, but as an objective practitioner, please summarise your preliminary observations and give a detailed account of further investigations to determine the reasons to treat BB yourself or to refer him to another authority.

Provisional observations by participant:

Consider each of the above statements. Work out what they all mean. Review the neuroanatomical, neuro-pathophysiological and ethical events associated with this problem. Then try to collate the information in such a way as to make a decision about what you are going to do.

Provisional diagnosis by participant:

Give the reasons for your 'intuitive diagnosis'?

Reasons for provisional diagnosis:

Declare what factors caused you to reach this preliminary conclusion?

Discussion with an RP:

When you are ready, arrange to see an RP to explain and discuss your early considerations and what you plan to do about them. Consider your actions very carefully because you will be graded for this by the RP.

What other information do you need?

What tests or investigations will you apply to elucidate, amplify and confirm your provisional views?

After discussion with the RP what is your subsequent diagnosis and course of action?

Subsequent findings and diagnosis:

What further 'hands on' clinical tests may you perform?

What are your likely findings?

What factors do you anticipate to help you to reach a subsequent diagnosis?

Show these factors to support your final diagnosis?

What will you recommend to BB?

How will you handle BB as an individual?

Courses of action and conclusive remarks:

Identify each one and explain how they shaped your conclusions.

References used to solve this problem:

List each one and refer to them throughout the text of your reply.
**ANATOMY & PATHOLOGY 252 - 93**  
**Problem Box No : 3 D**

<table>
<thead>
<tr>
<th>Participant:</th>
<th>Date:</th>
<th>Start time:</th>
<th>Finish time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify a Resource Person:</td>
<td>Name anyone else consulted ?</td>
<td>Grade by RP for participation</td>
<td>Grade by SC for presentation</td>
</tr>
</tbody>
</table>

**Previous clinical history:**

Grace and Horace Girdlestone are 41 year old twins who were separated at birth. Their family of origin were unable to support them because of chronic illness. GG and HG spent their childhood in Ontario and Eastern England respectively. GG was adopted by a family of oil workers, who later moved to Alaska. HG was fostered to a family who lived beside a canal and spent their time dredging sludge from the deep.

**Present clinical history:**

By middle-age, GG and HG were both suffering from chronic joint disease. They coincidentally decided to visit Australia to find one another. They were successful by 1993. Upon meeting in Western Australia, they were overjoyed and yet horrified by each of their predicaments. GG presents a serious involvement of RA, whilst GG is badly affected by OA.

**Comparative observations:**

GG & HG are both admitted as in patients at a hospital where you are a staff member.

You are asked to make a comparative review to elucidate the contrasting and differing etiology’s for presentation to a clinical management committee. This presentation is to include all appropriate details of connective tissue changes, evolution of signs and symptoms, and methods of treatment and prognoses for GG & HG.

**From these observations, prepare a detailed review of all appropriate phenomena to compare and contrast the case-histories of GG & HG.**

**Are there any genetic reasons for their present state of affairs ?**

**Is there some other explanations for these changes ?**

**Make a logical analysis to compare and contrast their circumstances.**

**Discussion with an RP:**

There are several opportunities for discussion with an RP. Use this time wisely.

**Subsequent findings and diagnosis:**

After further discussion with the RP and any other sources, explain the prognoses of GG & GH ?

**Conclusive remarks:**

What is the likely outcome for GG & GH ?

**References used to solve this problem:**

Give supporting references to validate each of your remarks.
### Previous medical and occupational history:

Chrysetabelle Gashworthy is 59 years of age. She is a mother of two grown up children, divorced, now living alone. Apart from a benign cystic retro peritoneal teratoma removed at the age of 10, until recently, CG has been reasonably well. She is a dietary fanatic, but despite this her weight has shown signs of fluctuation with an odd distribution, her skin colour has changed, and her bowel movements are unpredictable. Her earliest occupation was in a cleaning agency, where she used solvents to remove greasy stains from uniforms. From there, she went to a sweet factory, dipping products into colourful materials. After marriage and children, CG became a horticulturist, preparing flowers and vegetables for retail distribution.

### Present history:

As already mentioned, CG is showing signs of a prolonged clinical problem. Her emotional weak spot is where the teratoma was removed via laparotomy. She has put on weight in the abdomen, but lost it elsewhere. There appears to be swelling in one abdominal quadrant, which is troublesome between bouts of constipation and diarrhoea. At times of constipation there is a coincidence of "piles" with radiating pain down the outer side of the left thigh and medial aspect of the same leg. This is relieved when squatting, or in prone kneeling.

### Provisional observations:

- Summarise the case-history of CG.
- Make a list of any coincidental variables.
- Make a logical pattern of this information.
- Collate the information into main themes.

### Provisional diagnosis:

Review these observations into three hypotheses.

### Reasoned support for the three hypotheses:

Prior to discussion with an RP, group the hypotheses into a RANKED, or STAGED ORDER, with a well reasoned and logical deduction for this selection.

### Discussion with an RP:

Be able to discuss and defend the selected hypotheses with an RP. You will be graded for this.

### Subsequent findings:

Add any findings to the report after further consultation.

Construct a well documented presentation, to account for the evolving history of this problem. Include courses of action to be taken and conclusions about the likely outcome for CG.

Wherever possible, give supporting references to verify evidence used in relation to CG's problem.
Gloria Claptrap is a giggling physiotherapy student with an ebullient personality. GC suffers from pruritus at both ends of the alimentary tract, and is about to face an extremely dangerous situation.

Present history:

GC and a Nameless Friend have gone on a walking tour in the mountains of Southern NZ. Before setting off on a two-day trip in fine sunny weather, in an average diurnal temperature range of 7 & 17 C, GC & NF mention their plans to a Police-Ranger on the way. NF is wearing thermal underwear, wind-proof anorak, balaclava, knitted gloves, scarf and climbing boots, with two slabs of chocolate and a flask of whisky. GC is wearing summer underwear, a light-weight two-piece suit, a pink light-weight pullover, a loose-knit scarf, beanie, sunshades, woollen socks, sneakers, mittens, a tightly folded aluminium thermal blanket, 2 L of water, 4 bags of crisps and two apples!

GC & NF are walking happily along a narrow isolated ridge 2,000 metres above sea level at 1600 hrs on the first day. Suddenly the sky becomes dark and overcast with visibility reduced to less than 10 metres. Drizzle soaks GC & NF for half an hour, turning into sleet and snow, with a wind-chill factor caused by gale-force winds from the south. The temperature has dropped to -4 C, with a wind-chill factor of -16 C.

It had taken GC & NF 4 hours from the nearest settlement. With more isolation ahead of them they are unlikely to find their way back before the next day.

Physiological observations:

What will be the separate and primary physiological responses of GC and NF? What will be their separate and secondary physiological responses at, say 10 minutes, 30 minutes and 1 hour? What are their chances of survival throughout the night?

Survival options:

What are the chances of survival for GC & NF until dawn the next day if the same conditions persist for more than eight hours? Given these conditions, what can be done to increase their chances of survival? Give a detailed account of their individual autonomic and pathophysiological responses throughout.

Autonomic & pathophysiological summary:

Summarise the details of your observations and opinions regarding the predicament of GC & NF in preparation for discussion with an RP.

Discussion with an RP:

Document your discussion with the RP, identify a plan of action to account for all changes likely to occur to GC & NF.

Subsequent findings and physiological observations:

What will you arrange within the next 14 hours? Give a detailed account of their pathophysiological responses during this period. Detail the likely course of action that may be taken. Detail the pathophysiological changes and responses throughout. Detail any likely action to be taken to rescue or retrieve GC & NF? Give references to support the actions taken to solve it.
Clinical history:

Arthur Ursula is 47 years of age, married, with four children and an automotive engineer by occupation. During the past few years AU has noticed intermittent difficulty with vision, reportedly blurry with a spinning sensation, causing him to stagger alarmingly. AU has also noticed that his lower limbs are numb down one side with weakness and tremor down both sides. On entry to your rooms you notice that AU has a peculiar gait and that he is slow to sit down. AU has been to another specialist and has brought CAT & MRI scans outlined below. You decide to examine him to reach a conclusion about what may be wrong and to write a report recommending that he seek help beyond your practice.

The CAT & MRI scan images are outlined below.
They appear to coincide with some of the symptoms presented by AU. Assess and explain the results of the transient lesions occurring at points A to D and prepare to write a formal description in support of your observations. Firstly, look at the schematic outline of the spinal cord and then find sufficient evidence to support the level of the spinal cord under discussion. Secondly, write an outline of your clinical examination with a logical deduction about AU's condition.

Provisional observations?

Provisional diagnosis?

Reasons for provisional diagnosis?

Discussion with an RP:
After you have given some thought to the condition presented by AU, identify as much information as possible and then approach an RP to discuss the matter further, much as you would with an experienced professional colleague. Take note of what is discussed and use the information in your final document. (Remember that the RP will be evaluating your methodology).

Subsequent findings and diagnosis:
After further consideration, give any other information that you may find to reach a final conclusion.

Course of action taken and conclusive remarks:
Write a summary of your findings and recommended course of action.
At each opportunity, give references used to deal with AU's problem.
Limited history:

Andrea Strude is a 43 year old cartographer, she has come to you for urgent advice because she has been having gross sensorimotor dysfunction in various parts of her body. She looks extremely ill and staggers alarmingly whilst walking.

OE her presenting S&S's coincide with those outlined in the diagram below. Please write a formal report which gives the details of your procedures throughout, with supporting references to validate your observations and conclusions.

On examination it is clear that AS is under attack from expanding lesions at A & B, with an inflammatory reaction at C, each of which is outlined above.

Provisional observations:

Write a suitable scenario to explain the various phenomena threatening AS.

Provisional diagnosis:

Declare and be prepared to explain any intuitive conclusions you may have already reached about AS.

Objective reasons for provisional diagnosis:

Be able to summarise how you objectively reached a provisional diagnosis.

Discussion with an RP:

When you are ready, summarise your procedures and findings prior to discussion with the RP. Bear in mind that you will be graded for the quality of your method.

Subsequent findings and diagnosis:

After further consideration and inquiry, summarise your efforts.

In a cogent summary, detail your courses of action and conclusive remark.

At each opportunity, include references used to deal with AS's problem.
### ANATOMY & PATHOLOGY 252 - 93

<table>
<thead>
<tr>
<th>Participant:</th>
<th>Date:</th>
<th>Start time:</th>
<th>Finish time:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Identify a Resource Person:</th>
<th>Name anyone else consulted?</th>
<th>Grade by RP for participation</th>
<th>Grade by SC for presentation</th>
</tr>
</thead>
</table>

### Previous clinical history:

Flatulent Stanley Gothshawke, a 52 year old saxophonist, is happily married, with eight children. Although corpulent, until recently FSG was considered to be generally well, having only visited a dentist twice and a general practitioner three times in his lifetime.

### Present clinical history:

FSG was sitting quietly in front of his favourite Hi-Fi, listening to Kenny G, when he turned to his spouse to complain of a severe headache. With much TLC, FSG was persuaded to go to bed. On his way upstairs, he staggered against the banisters and slumped onto the landing. He was lifted to his bed, where he remained in a state of deep unconsciousness. With great concern, Mrs G sent for an ambulance and FSG was rushed off to hospital. OE, the resident found the following signs. FSG was in a deep coma, his face flushed, his right cheek billowed during respiration. His respiratory rate was 14 per min, becoming rapid and deep, with intermittent periods of no breathing whatsoever. His pulse rate was 50 BPM. The corneal reflex was absent on one side, but neither pupil reacted to stimulation by flashlight. On further investigation, FSG's head appeared to roll over to one side, with a flattened appearance on the face of that side. Observable variation was found in muscle tone of the two sides of the body, with more in the upper than lower limb of one side. Abdominal reflexes were absent on one side, with a + Babinski on the same side.

### Provisional observations:

Give a full pathophysiological account of each of the signs outlined above, also present any further tests that could be applied to determine further treatment to be applied to FSG.

### Provisional diagnosis:

After consideration of the provisional findings, give supporting evidence to justify a provisional diagnosis for FSG.

### Immediate treatment & early changes expected in FSG's condition:

Summarise FSG's immediate condition with an indication of the various treatments which may be applied:

- Firstly in 'Casualty'.
- Secondly wherever else he may be moved to.
- Thirdly, a brief outline of changes in FSG's condition, with a review of the most appropriate physiotherapy regime to be applied during the next few weeks.

### Discussion with an RP:

When ready, arrange to see an RP. Take the information accumulated about FSG, with supporting evidence for each concept. Discuss the situation thoroughly and carefully note any directions given.

### Post-RP action:

After discussion with the RP, other actions may be considered advisable. Give an account of them.

### Courses of action taken and conclusive remarks:

In review, give a final summary of FSG at twelve weeks after the appearance of the first signs, outlining a prognosis for the next two years.

### Wherever possible:

Intersperse your work with supporting references and evidence used to deal with FSG's situation.
CHAPTER 4

METHOD

4.1 The purpose of this study

The purpose of the study was threefold. Firstly, to validate that parochial ICALP materials can be developed and evaluated to replace traditional lectures in anatomy. Secondly, to empower ICALP materials for the acquisition of 2-D cognitive information to be transferred into an effective 3-D anatomical skill. Thirdly, to investigate the relative cost-effectiveness of traditional methods of learning in anatomy with the development and presentation of ICALP and Test Items in a CMLE.

4.2 Learning by ICALP alone

ICALP learning strategies were applied and the interaction rates of individuals were recorded throughout this project. The variables shown in Table 2 were recorded as data to identify the determinants of achievement in anatomy ICALP modules and Test Items.

Table 2. Variables recorded for ICALP learning strategies

<table>
<thead>
<tr>
<th>Learning Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click:</td>
<td>a 'MouseDown' click to answer a question</td>
</tr>
<tr>
<td>Interaction clicks:</td>
<td>the average number of clicks per minute</td>
</tr>
<tr>
<td>Success clicks:</td>
<td>the average number of correct clicks per minute</td>
</tr>
<tr>
<td>Error clicks:</td>
<td>the average number of errors per minute</td>
</tr>
<tr>
<td>Learning time:</td>
<td>the median time taken to complete an ICALP session</td>
</tr>
</tbody>
</table>
Table 2. Continued.

<table>
<thead>
<tr>
<th>Learning score:</th>
<th>the average score achieved at the end of an ICALP session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions:</td>
<td>the number of definitive ICALP sessions attended</td>
</tr>
<tr>
<td>Average session:</td>
<td>average time spent at each definitive ICALP session</td>
</tr>
<tr>
<td>Test data</td>
<td></td>
</tr>
<tr>
<td>Pretest:</td>
<td>a test applied prior to a learning period</td>
</tr>
<tr>
<td>Posttest:</td>
<td>the same test applied at the end of a learning period</td>
</tr>
<tr>
<td>Re-test at 60 days:</td>
<td>the same test applied after a delay of 60 days</td>
</tr>
<tr>
<td>Re-test at 120 days:</td>
<td>the same test applied after a delay of 120 days</td>
</tr>
<tr>
<td>Average test result:</td>
<td>an average of the above test items</td>
</tr>
</tbody>
</table>

4.3 Research design

To provide valid results, the research project was divided into three manageable phases. The first phase was used for the creation of appropriate software. The second phase was devoted to the accumulation and evaluation of data from individual learners. The third phase was confined to a quantitative analysis of accumulated data to examine learning styles and determine the cost-effectiveness of the methods used throughout the research project.

4.4 Phase I: Completion of the literature review and creation of software.

Phase I was devoted to the development of suitable software to meet the requirements of the anatomy syllabus for undergraduate and postgraduate physiotherapy students. The software used for ICALP
(interactive computer-assisted learning program) materials were predominantly based upon a HyperCard® delivery system via SOCCER (self-operated computer controlled educational resource) in a CMLE (computer-managed learning environment), whilst the same materials were projected as the core content of lectures using DataShow® and Microsoft® PowerPoint® for their presentation.

To verify the hypotheses of this study, quantitative data was obtained from ten discrete areas of the anatomy syllabus described in Section 4.13 below. From this content, suitable ICALP modules were developed and applied in three ways during 1992. Firstly, a pattern of random intermittent subdivision was devised for the ten defined areas for presentation to the undergraduate (UG) population categorised into lecture and computer groups. Secondly, the ten areas of ICALP materials were progressively dispensed to the computer groups in the CMLE whilst the same ICALP materials were presented by overhead projection to the lecture groups, with mutual exclusion of each to the other at any one time. Thirdly, the ICALP modules were used as source materials for the preparation of pre and posttests in each of the ten areas of study for comparative assessment of the lecture and computer learning groups.

To validate the 1992 results, the same regime was re-applied to the succeeding UG population of students in 1993.

In 1992, the lecture and computer group selections were made either alphabetically, or randomly, by a member of staff not involved in the study. In 1993, the same regimen was applied, with the exception of self-selection for studies of the cerebellum outlined in Section 4.13.7, and an ICALP option only for Sections 4.13.8; 4.13.9; and 4.13.10.
First and second year undergraduate physiotherapy students of anatomy and pathology in 1992 and 1993 were the main research population. First year students were classified as UGI and second year students as UG2. The UGI and UG2 populations of 1992 were n=87 and n=79 respectively. Unfortunately, a change of policy occurred at the end of 1992 which effectively removed the UGI students from this research project. Therefore, with the exception of the upper and lower extremity items applied to both groups, data for the remaining studies were derived from the efforts of the UG2 populations of 1992 (n=79) and 1993 (n=73). For further information please refer to Tables 55-1, 55-2 (pp 330 & 331), and 72 (p 362).

Throughout these experiments, the research population was randomly sub-divided into either Lecture or ICALP learning groups for each of the ten discrete areas of study. At the end of each definitive area of experimentation, a cross-over style was initiated to exchange the members of the Lecture group with the ICALP group, and vice versa. In this way, on no occasion were subjects permitted to continue without a complete reversal of learning style at the end of each of the ten discrete areas of study.

This regimen of reversal was sustained by an interchange of privileges via SOCCER which enabled specific ICALP materials to be individually presented to half of the randomly selected cohort, who were then denied access to anatomy lectures. Conversely, the remaining half of the cohort became the Lecture group, who were denied access privileges to the CMLE. As already mentioned, to sustain and verify quantifiable data, the Lecture and ICALP groups were randomly re-selected at the end of each of the ten discrete areas of study. Thus, all members of the student
population were rotated between Lecture and ICALP groups at staged intervals throughout any given semester to ensure that all subjects were equally exposed to both methods. The recall of information was objectively evaluated by testing the whole student population at predetermined intervals. With the exception of the UG1 cohort, the events of 1992 were repeated by the UG2 students of 1993 to validate previous findings by replication in another population.

4.5 Phase II: The accumulation and evaluation of data from individual learners

The twenty-five workstations in the CMLE were made available to individual ICALP students. Before commencement of each of the ten discrete areas of study, the cohort was pretested under formal supervision and then randomly allocated to Lecture or ICALP learning groups. After completion of the pretest, the categories of selection were divided into Lecture and ICALP learning groups. For the remainder of each experimental procedure, the Lecture group was denied access to the CMLE whilst members of the ICALP group were denied access to lectures.

During the allocated period of discrete learning, the resultant data of each of the ICALP learners was accumulated for subsequent analysis. At the end of the period, both groups were again required to undertake the pretest, now declared to be its posttest. In this way, quantitative data was obtained from pre and posttest items for comparative analysis of the two groups. This regime was applied for the ten discrete areas of the anatomy and pathology syllabus in 1992 and replicated to the cohort of 1993. In both academic years, the same test was unexpectedly repeated at 60 and 120 day intervals after studying the central nervous system to compare
the level of recall by the two groups. These data are found in Tables 55-1 and 55-2 (pp 330 & 331).

4.6 The influence of 2-D information to develop a 3-D skill
The Group Embedded Figures Test (GEFT) was administered in the first and last weeks of 1992 and 1993 as a possible device to predict their ability to transpose 2-D information into a 3-D skill. These results were extended to investigate the influence of 2-D and 3-D computer-assisted simulations with the outcome of a measurable 3-D skill in laboratory exercises. Hence, pre and posttest results achieved in ICALP sessions were compared with pre and posttest results achieved in 3-D laboratory experiments related to the Cardio-Thoracic, Lower Extremity, and Central Nervous Systems in Figures 122 to 137 (pp 276-284) and Tables 55-1, 55-2 and 72.

4.7 Quantitative and qualitative feedback
To qualitatively evaluate the psycho-social background and effect of this project upon the learning processes of the study populations in 1992 and 1993, the FeedBack Instrument outlined in Sections 3.39 and 4.15 (pp 224 & 261), was administered to all persons involved in this study. The feedback data retrieved from the 1992 and 1993 populations was collated and processed by the Lertap System (Nelson, 1986). The information disclosed in Chapter 5, was applied in a modified Lertap format in Figures 163 to 180 (pp 385-395), and Tables 55-1, 55-2, and 72.

4.8 Comparison of pre-entry profiles with subsequent results
An investigation was also undertaken to identify any predisposing relationship between pre-entry scores in English, English Literature and Human Biology (EEHB) and Mathematics, Chemistry and Physics
(MCP) with the final outcome of studies in anatomy and pathology at the end of second year. Data obtained from the FeedBack Instrument (Figure 113, p 227) is classified under the headings EEHB and MCP from the study populations of 1992 and 1993. Although the UG2 study populations for this project in 1992 and 1993 were n=79 and n=73 respectively, pre-entry scores in the EEHB and MCP categories could only be verified for n=73 in 1992 and n=66 in 1993. On a few occasions, the average score achieved in the EEHB and MCP categories were at par for certain individuals in this project. As a result, six scores were evenly distributed between the two groups, two in 1992 and four in 1993.

The EEHB and MCP data explore the 2-D and 3-D capabilities of the two groups to determine if any pre-eminence exists by either category. This information is disclose in Sections 5.9.2 and 5.9.3 and in Tables 79 to 89-90 (pp 412-424), some of which show ANCOVA data to compare pre-entry results with unadjusted and adjusted scores thereafter.

4.9 Phase III: Quantitative analysis of accumulated data to examine learning styles and determine the cost-effectiveness of the methods used throughout this research project.

As already described, data acquired from Phases I & II was thoroughly screened to assess the academic profiles of the various participants, and to assess how individuals were able to transfer cognitive, 2-D information into an effective 3-D skill. These data, together with an account of expenditures utilised over a four year period in the CMLE, were combined with the developmental history of ICALP, Test and FeedBack Items to determine the relative cost-effectiveness of SOCCER, the CMLE, and ICALP materials used throughout this study (see Tables 73-1 to 73-6, pp 364 to 375; and Table 74, p 379).
4.10 Statistical procedures used for this project

From discrete segments of data retrieved from by the CMLE via Microsoft® Excel© throughout 1991, 1992 and 1993, information was stored as a primary database using a format used by the SuperANOVA© program (Abacus Concepts; Gagnon, Feldman, Finzer, Haycock, Hofmann & Roth, 1991). This database provided a continuous stream of nominal and informative data by categories and strings, with immediate access to individual and group results from pre-post and delayed re-test scores for comparison with other indices throughout this project.

Results of these data were analysed by a variety of procedures for each of the ten defined areas of anatomy studied in 1992 and 1993. Standard descriptive statistics were applied to each of the lecture and computer learning groups. These data were used to calculate effect sizes and compute analyses of variance to derive correlation ratios.

In each case, the effect size was deduced by subtraction of the mean score of the ICALP group from that of the Lecture group, the result of which was then divided by the standard deviation of the Lecture group. In the same way, each correlation ratio was acquired by division of ‘between’ groups with the total ‘sum of squares’ from data provided by SuperANOVA©.

Analysis of covariance (ANCOVA) procedures were applied to adjust posttest mean values, using pretest scores as covariates (Popham & Sirotnik, 1992). The data extrapolated from the SuperANOVA© database were also presented by box plot, using the Statistical Package for the Social Sciences (SPSS®) created by Nie, Hull, Jenkins, Steinbrenner and Brent (1980), extended by Norusis (1990). The box plots used in this
project were constructed from the SPSS® version for Windows, Release 6.0. In this way, box plots were constructed from pre and posttest data to enable visual interpretation of respective inter-group test score differences.

4.11 Software and courseware development
From 1989 to 1993, software items were evolved to meet the requirements of this research project. From the outset, the hours devoted to the development of software were scrupulously accounted for by the disciplined use of a computerised diary to account for each event. These events are summarised in Tables 3 to 10 (pp 249-252), and Tables 73-1 to 73-6, and 74 (pp 366-377, & 381) to show the logistics of each item by name, number of screens, size of the package, the time taken for its evolution and modification, together with the average time of use by the student population.

Courseware production was categorised into the seven clusters of software shown in Tables 3 to 10. Each cluster representing a particular function, or collection of ICALP and pre-posttest items. The hard-core administrative cluster is shown in Table 3, namely SOCCER, ScoLar, Comp-Tests, Comp-E-Track, MCQTI and FeedBack Items. The remaining clusters represent anatomical and pathological nodes of study, namely; head, face, neck and back (Table 4); upper extremity (Table 5); cardio-respiratory system (Table 6); trunk and lower extremity (Table 7); central nervous system (Table 8); embryology and peripheral nervous system (Table 9); and pathology (Table 10).
### 4.12 Courseware production

**Table 3. SOCCER, ScoLar, Test-Items, and Feedback**

<table>
<thead>
<tr>
<th>Title</th>
<th>No of screens</th>
<th>Stack size</th>
<th>Developer time</th>
<th>User time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOCCER</td>
<td>92</td>
<td>453K</td>
<td>36 hrs</td>
<td>596 hrs</td>
</tr>
<tr>
<td>ScoLar</td>
<td>45</td>
<td>226K</td>
<td>14 hrs</td>
<td>N/A</td>
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<tr>
<td>CompTest-I-93</td>
<td>144</td>
<td>1221K</td>
<td>7 hrs</td>
<td></td>
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<tr>
<td>CompTest-II-93</td>
<td>130</td>
<td>860K</td>
<td>3 hrs</td>
<td></td>
</tr>
<tr>
<td>CompTest-I-94</td>
<td>149</td>
<td>925K</td>
<td>5 hrs</td>
<td></td>
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<tr>
<td>CompTest-II-94</td>
<td>124</td>
<td>961K</td>
<td>5 hrs</td>
<td>1342 hrs</td>
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<td>Comp-E-Track 1</td>
<td>45</td>
<td>84K</td>
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<tr>
<td>Comp-E-Track 2</td>
<td>105</td>
<td>129K</td>
<td></td>
<td></td>
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<tr>
<td>Comp-E-Track 3</td>
<td>105</td>
<td>102K</td>
<td>12.5 hrs</td>
<td>62 hrs</td>
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<tr>
<td>MCQTI-2.1</td>
<td>105</td>
<td>148K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCQTI-2.2</td>
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<td>148K</td>
<td></td>
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<td>MCQTI-2.3</td>
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<td>FeedBack-1</td>
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<td></td>
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<tr>
<td>FeedBack-2</td>
<td>9</td>
<td>72K</td>
<td></td>
<td></td>
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<td>FeedBack-3</td>
<td>9</td>
<td>66K</td>
<td>22.5 hrs</td>
<td>58 hrs</td>
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**Table 4. Head, face, neck and back**

<table>
<thead>
<tr>
<th>Title</th>
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<th>Stack size</th>
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<th>User time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head&amp;Face</td>
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<td>934K</td>
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<td>69 hrs</td>
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<tr>
<td>Neck</td>
<td>118</td>
<td>608K</td>
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<td>53 hrs</td>
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<tr>
<td>Back</td>
<td>125</td>
<td>652K</td>
<td>43 hrs</td>
<td>92 hrs</td>
</tr>
<tr>
<td>HeFaNeBa-Pre &amp; Posttest</td>
<td>148</td>
<td>902K</td>
<td>4.5 hrs</td>
<td>104 hrs</td>
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Table 5. Upper extremity

<table>
<thead>
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<tr>
<td>ShArm</td>
<td>91</td>
<td>880K</td>
<td>105 hrs</td>
<td>1215 hrs</td>
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<tr>
<td>ArmFor</td>
<td>83</td>
<td>800K</td>
<td>97 hrs</td>
<td>652 hrs</td>
</tr>
<tr>
<td>ForHand</td>
<td>74</td>
<td>720K</td>
<td>72.5 hrs</td>
<td>784 hrs</td>
</tr>
<tr>
<td>HandFun</td>
<td>117</td>
<td>1024K</td>
<td>114 hrs</td>
<td>1274 hrs</td>
</tr>
<tr>
<td>HandFun-Pre &amp; Posttest</td>
<td>135</td>
<td>928K</td>
<td>7.25 hrs</td>
<td>479 hrs</td>
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<tr>
<td>UpperExt-Pre &amp; Posttest</td>
<td>186</td>
<td>1408K</td>
<td>8 hrs</td>
<td>1081 hrs</td>
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Table 6. Cardio-respiratory system

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<tr>
<td>Heart</td>
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<tr>
<td>ECG</td>
<td>69</td>
<td>286K</td>
<td>40 hrs</td>
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<tr>
<td>Heart-StrucFun</td>
<td>30</td>
<td>283K</td>
<td>45 hrs</td>
<td>138 hrs</td>
</tr>
<tr>
<td>Heart Sounds</td>
<td>24</td>
<td>147K</td>
<td>30 hrs</td>
<td>74 hrs</td>
</tr>
<tr>
<td>Cardio</td>
<td>70</td>
<td>648K</td>
<td>75 hrs</td>
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</tr>
<tr>
<td>Cardio-Pre &amp; Posttest</td>
<td>107</td>
<td>880K</td>
<td>3.5 hrs</td>
<td>291 hrs</td>
</tr>
<tr>
<td>Lungs</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Resp</td>
<td>73</td>
<td>720K</td>
<td>75 hrs</td>
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<td>Resp-Pre &amp; Posttest</td>
<td>132</td>
<td>865K</td>
<td>2.8 hrs</td>
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<tr>
<td>CardioThoracicSurfAnat</td>
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<td></td>
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<tr>
<td>SurfThora</td>
<td>89</td>
<td>792K</td>
<td>47.5 hrs</td>
<td>1212 hrs</td>
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<tr>
<td>SurfThora-Pre &amp; Posttest</td>
<td>116</td>
<td>896K</td>
<td>4 hrs</td>
<td>235 hrs</td>
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<tr>
<td>CardioRespSurf Pre &amp; Posttest</td>
<td>180</td>
<td>1398K</td>
<td>3.5 hrs</td>
<td>288 hrs</td>
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Table 7. Trunk and lower extremity

<table>
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<tr>
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<tbody>
<tr>
<td>SurfAnat-Trunk</td>
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<td>SurfAnat-LowEx</td>
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<td>SurfAnatTrLowEx Pre &amp; Posttest</td>
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<td>593K</td>
<td>78 hrs</td>
<td>523 hrs</td>
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<tr>
<td>TorsoMorph</td>
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<td>592K</td>
<td>83 hrs</td>
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<td>PelSkel</td>
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<td>792K</td>
<td>75 hrs</td>
<td>512 hrs</td>
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<td>TrunkHip&amp;Thigh</td>
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<td>912K</td>
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<td>Knee&amp;Leg</td>
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<td>Leg&amp;Foot</td>
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<td>142</td>
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</table>

Table 8. Central nervous system

<table>
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<tr>
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<td>29 hrs</td>
<td>352 hrs</td>
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<tr>
<td>BrainStem&amp;Cerebellum</td>
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<td>168K</td>
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<tr>
<td>CranArt&amp;Nerves</td>
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<td>192K</td>
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<td>152K</td>
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<tr>
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<td>216K</td>
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<tr>
<td>SinMen&amp;SpiCor</td>
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<tr>
<td>Neuro Pre &amp; Posttests 1-2-3</td>
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<td>1049K</td>
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<tr>
<td>Cerebellar-Structure</td>
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<td>Cerebellar-FunDys</td>
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<td>Cerebellar-TFTI</td>
<td>14</td>
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### Table 9. Embryology and peripheral nervous system

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<td>Nerve</td>
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<td>Nerve-Pre &amp; Posttest</td>
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<td>376K</td>
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<tr>
<td>BraPlexus-Pre &amp; Posttest</td>
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<td>520K</td>
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<td>58</td>
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<td>Reflex-TFTI</td>
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<td>98K</td>
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<td>131</td>
<td>612K</td>
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### Table 10. Pathology

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<td>GeneticPatho</td>
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<td>268K</td>
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<td>EndoPatho</td>
<td>156</td>
<td>808K</td>
<td>74.5 hrs</td>
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<td>OncoPatho</td>
<td>93</td>
<td>320K</td>
<td>58 hrs</td>
<td>165 hrs</td>
</tr>
<tr>
<td>Comp-E-Track Pre &amp; Posttest</td>
<td>130</td>
<td>105K</td>
<td>12.5 hrs</td>
<td>62 hrs</td>
</tr>
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</table>
4.13. Ten discrete areas of study
ICALP, pre and posttest items were arranged to meet the ten discrete areas of learning reviewed in Tables 73-1 to 73-6 (pp 366-377). These discrete areas were focused upon: the upper extremity; the cardiac system; the respiratory system; cardio-thoracic surface anatomy; the lower extremity and its surface anatomy; the central nervous system; the structure, function and dysfunction of the cerebellum; the embryology of peripheral nerves; the structure, function and dysfunction of peripheral nerves; and a clinical study of clinical reflex behaviours.

4.13.1 Upper extremity
In 1992, the second year population of physiotherapy students (n=79) was randomly subdivided into Lecture and ICALP learning groups for a five week period to compare and evaluate the impact of three ICALPs used for the presentation of anatomical information related to the upper extremity. To compare and evaluate the progress of the two groups, the computer-based Upper Extremity Test was administered under academic supervision in the CMLE as pre and post-test items.

Throughout the five week period, the Lecture group was denied access to the CMLE whilst the ICALP group was allowed freedom of access to SOCCER in the CMLE, but was denied access to lectures in anatomy during the proscribed period.

Three ICALPs modules were developed for this purpose, each related to the shoulder and arm (ShArm), the arm and forearm (ArmFor), and the forearm and hand (ForHand). The three ICALPs were sequentially applied via OHP to the Lecture group, whilst the same materials were
made available to the ICALP group with unlimited access to the CMLE throughout the allocated learning period.

After the posttest for the upper extremity session, the Lecture-ICALP arrangement of this population was reversed without prior warning to study hand function (HandFun). The re-designated Lecture and ICALP groups were pre and posttested over a two week period in the manner previously described. To validate these results, the same regimen was re-applied in 1993.

4.13.2 Cardiac system
The same regime previously described for the Upper Extremity was applied over a three week period in 1992, and re-applied in 1993.

4.13.3 Respiratory system
The same regime described for the Upper Extremity and Cardiac System was applied over a three week period in 1992, and re-applied in 1993.

4.13.4 Cardio-thoracic surface anatomy
In the first semester of 1992, the second year population was randomly divided into Lecture and ICALP learning groups. Normally, two weeks of teaching and learning were applied to learning cardio-thoracic surface anatomy, which include four hours of lectures and four hours of laboratory experience.

As previously described, ICALP materials were used to present core information to the Lecture group, who were denied access to the CMLE. During the same period, the ICALP group were denied entry to the lectures, but allowed free access to the same materials via SOCCER in
the CMLE. At the end of the second laboratory session of the specified
two-week period, pairs of students were rotated through a 3-D practical
*viva voce* examination immediately followed by the 2-D posttest under
supervision in the CMLE.

As previously described for validation purposes, this regime was re-
applied to a subsequent cohort in 1993.

4.13.5 **Lower extremity and its surface anatomy and the GEFT**
To investigate the hypothesis that ICALP materials can be used to
replace lectures when teaching surface anatomy to undergraduate
physiotherapy students, the transposition of 2-D cognitive theory into a
3-D psycho-motor skill, GEFT and previous anatomy scores were
correlated with other scores acquired in a five week learning period.

Prior to the commencement of these experiments, an inventory of 120
surface anatomy features of the lower limb were identified and tabulated.
From this inventory *HyperCard®* Stacks were developed to present each
feature in an ICALP form for three designated regions of the lower limb.
The three ICALP stacks were converted into overhead projections for the
presentation of the identical 2-D images and features from the inventory
via *DataShow* to Lecture sub-groups.

From the content of the three ICALP stacks, a 2-D diagrammatic pretest
was constructed to evaluate the acquisition of knowledge in surface
anatomy by the total study population. The same 2-D pretest was re-
formatted to re-test the same information to coincide with the three
regions of the lower extremity.
To meet the requirements of individual members of each ICALP sub-group, the 25 workstation CMLE was exclusively made available for their use, under supervision, at the beginning of each two-hour session. Simultaneously, the Lecture sub-group received the same information in an OHP format driven by a Macintosh computer mounted on a portable DataShow console.

At the commencement of week one, the entire study population undertook the 2-D diagrammatic pretest together with the GEFT to categorise field-dependent, and field-independent perceptual abilities. Throughout weeks 2, 3 & 4 OHP projection was used to present the same information to Lecture sub-groups as that delivered to the ICALP sub-groups via SOCCER.

In week five, all subjects were re-combined to take the original 2-D test and a practical 3-D viva to evaluate the ability to transpose previously learned 2-D images into a 3-D practical skill. To control the learning effects of the test-retest strategy, 10% of the 2-D pretest was repeated during weeks 2, 3 & 4.

Palpation and landmark surface identification skills were practised during weeks 2, 3 & 4, with some landmarks deliberately left unpractised and obscure to the Lecture and ICALP sub-groups. In week 5, 2-D computer-tests were applied again in combination with a practical examination of individual 3-D palpation and landmark skills by two independent staff members.

Analyses of variance were undertaken to look for a relationship between test scores and subject areas of the three regions of the lower extremity.
This study was applied to the UG1 cohorts in the second semester of 1991, 1992 and 1993. To avoid any bias, the selection and distribution of subjects into three study groups and ICALP and Lecture sub-groups, was carried out by a staff member not involved in the study. Furthermore, the collection and recording of scores from the various tests and the supervision of the ICALP sub-groups in the CMLE, was carried out by two persons not involved in the study.

4.13.6 Central nervous system

To compare the effectiveness of learning the anatomy of the central nervous system by ICALP and Lectures, the criteria previously described were separately applied to second year physiotherapy students in 1992 and 1993. In each case, the cohort was sub-divided into Lecture and ICALP learning groups. As previously described, Lecture groups were given identical information via formal lectures and OHP, but denied access to the CMLE, whilst ICALP groups were denied admission to lectures but allowed unlimited access to the CMLE.

The content of the ICALP materials of the CNS were formatted into four subtests, each administered under controlled conditions, as a pretest, immediate posttest, and re-test at 60 and 120 day intervals after the appearance of the first posttest.

In this way, quantified information was obtained in 1992 and 1993, where subjected to the same regime over a five week learning period followed by an unexpected re-test design at 60 and 120 day intervals to measure any attenuation of knowledge.
4.13.7 Cerebellar structure and function

Because of its disparity with the remainder of the central nervous system, the structure, function and dysfunction of the cerebellum was treated as a separate entity. To meet the purposes of this project, two distinct ICALP modules were developed, one to present cerebellar structure, the other to present cerebellar function and dysfunction.

In the way previously described, a cerebellar pre-posttest system was developed with a specific TFTI. Normally, three weeks of academic study are allocated to this task, each week containing three hours of lectures followed by a two hour laboratory period. With the opportunities provided by the CMLE outlined in Table 73-5 (p 375), the cerebellar materials were applied as a pilot study in 1991, then used as a research instrument in 1992, followed by a student-selected procedure in 1993. In this way, the cerebellar study provides a three-stage approach to separate UG2 populations; firstly as a field test in 1991; secondly to comply with the pre-posttest design of randomly selected Lecture and ICALP study groups in 1992; finally delivered as a self-selection Lecture-ICALP option in 1993.

In each case, the cerebellar pretest and TFTI was administered on the Friday prior to the commencement of the allocated three week period of study. From then onwards, the designated Lecture group was denied access to the CMLE, whilst the ICALP group were denied entry to the nine hours devoted to cerebellar lectures.

At the end of the three week period, the final two hour laboratory session was immediately followed by administration of the posttest to all subjects under controlled conditions.
In the second semester of 1993, the same provision was made except that the total population was invited to arrange for self-selection into either Lecture or ICALP groups. In this case, seven subjects chose to join the Lecture group, whilst 66 subjects chose to become members of the ICALP group.

4.13.8 Embryology of the peripheral nervous system
At the beginning of the second semester in 1992, the second year population was divided into Lecture and ICALP groups. As described previously, a computerized pretest was administered before the formal period of instruction, followed by the same test reformatted as a posttest.

In 1993, although the same pre-posttest design was applied for this topic, it was decided that no lectures would be given but that its ICALP would become the basis of a Problem-Based Learning (PBL) strategies administered to both research groups in the randomised format previously described.

4.13.9 Structure, function and dysfunction of peripheral nerves
The same regime was applied in 1992 and 1993 for this element as described in Section 4.13.8.

4.13.10 Reflexes
The same regime was applied in 1992 and 1993 for this element as described in Sections 4.13.8 and 4.13.9.

4.14 Problem-based learning strategies
In 1992, a problem-based approach was developed to involve students with their own rate of progress in a simulated environment of discovery
learning designed to show that there is no single explanation to presenting phenomena from individual patients. From this strategy, a philosophy was generated to accept that there is no black and white, all-embracing recipe for the treatment of any single condition and to move the learner away from the risks of a linear way of thinking.

Lectures normally delivered in Semester II of second year were converted into a problem-based learning format. Thus, in Semester II 1992 and 1993, some twenty-eight problems were developed and released in groups of four. Each group of randomised problems was predetermined, as shown in Figure 119 (p 231), and individually delivered to the learner for selection by a click on the problem question assignment box, as shown in Figures 17, 18, and 118 (pp 152 & 230).

Under the aegis of the CAUT research grant, Resource Persons (RP) were employed to take part in this enterprise. The minimum requirements of an RP were stipulated to be a postgraduate physiotherapist with at least two years of professional experience, currently in the final semester of a postgraduate qualification. Of the seven RPs utilised in this way, two were PhD candidates, one was an MSc student, the remaining four were undertaking Postgraduate Diploma's, of which two were in Manipulative Therapy and two in Sports physiotherapy. The functions of an RP were twofold, primarily to supplement undergraduate PBL by first-hand clinical experience in laboratory sessions, with a secondary role to observe the process and submit independent results for assessment.

Twenty-eight problems were generated in groups of four to coincide with seven areas of PBL for UG2 students in Semester II of 1992-3. At
the commencement of each two week study period, a collection of four problems was delivered via SOCCER. This technique was used to enable individual learners to print a copy of their own designated problem in the CMLE and then to decide how to deal with it. At this point, it is important to note, that although Apple Image Writers were provided for this purpose, the specific costs of such printing were self funded by the students concerned.

During the two-weeks allocated to the solution of each problem, each learner was empowered to approach an allocated RP for discussion prior to more formal investigation with an RP in two subsequent four-hour laboratory periods.

At the end of each PBL study period, student solutions were handed in for assessment at the same time as staff solutions were published on the second year notice board. One week was set aside for the RPs and Subject Controller to grade the previous group of problems prior to them being returned for further discussion. Throughout these episodes, a log was kept by the Subject Controller and each RP to account for all learner interactions, which were then recorded to account for the PBL ability of each participant.

4.15 Learner feedback
To gain an insight into learner reaction to the strategies used for teaching and learning anatomy, the FeedBack Instrument previously described was used for second year students in 1992 and 1993.
4.16 Replication studies and retention of knowledge
As previously described, to validate previous results obtained from studies in 1991 and 1992, the same regime was applied to the first seven of the ten discrete areas to obtain data for replication purposes. Furthermore, an identical regimen was applied in 1992 and 1993 to studies of the CNS. The same test items were formatted into four devices, each of which was unexpectedly delivered as pre, post, and re-test items at 60 and 120 days after administration of the first posttest.

4.17 Educational cost-benefits and cost effectiveness
To contrast the educational cost-benefits of learning anatomy and pathology by lecture with individuals using ICALP and Test Items via SOCCER, data was assembled to compare the cost-effectiveness of methods used in this project. A modification of Levin’s (1984) three-stage approach was formulated to review the costs of the learning environment for the participants of this project. Note was also taken of the methods used by Abik (1994), who used Levin’s method for the presentation of CAL data as an alternative mode of learning in chemistry by Indonesian Senior Secondary School students. These techniques were applied to explain budgetary and salary information recorded for correlation with student results incorporated into a computer network costs model.

4.18 Computer network costs
When the hypotheses of this project were formulated in 1989, it was envisaged that the educational and administrative cost-benefits mentioned above could be categorised as pro-rated costs of the use of the CMLE by UG1, UG2 and PG physiotherapy anatomy and pathology students from the beginning of Semester I, 1991, to the end of Semester
I, 1994 (Tables 73-1 to 73-6, and Table 74). The proposed pro-rated costs would account for the Network Administrators salary, the acquisition of hardware at CMLE workstations, software costs, recurrent annual costs of support staff, consumable costs, together with a scale of depreciation and replacement costs.

These data were to be applied to resolve pro-rated costs of the CMLE by UG1, UG2 and PG physiotherapy anatomy and pathology students whilst learning, revising and being tested. Furthermore, these data were used to show the number of hours spent in the CMLE and to express the unit costs per hour at workstations by physiotherapy students when learning anatomy and pathology.

However, adequate assessments were made of the time spent in the preparation and presentation of lecture materials, and the grading and marking of tests and examinations. The time spent in the development and presentation of SOCCER, ICALP, Test and FeedBack items per unit hour of effort in the CMLE was recorded in Tables 73-1 to 73-6.

To evaluate educational effectiveness, account was taken of student activities and achievements per unit hour, comparing the time spent in lectures and post-lecture learning and revision of a traditional scenario, with that spent at computer workstations and time spent in revision and learning in a CMLE (Tables 73-1 to 73-6, and 74).

4.19 Time taken to prepare written and practical examinations
In this project, the time taken by an experienced lecturer to prepare a two-hour written examination paper was recorded for comparison with the time spent by experienced lecturing staff to prepare, mark and grade
tests in a traditional anatomy learning environment. These data are presented in Tables 73-1 to 73-6, and Table 74.

4.20 Time taken to prepare computerized examinations
Using the facilities of SOCCER, the time taken by an experienced academic staff member to prepare computerized tests in anatomy was also recorded. Using images from ICALP learning materials, the time taken by an experienced staff member to prepare diagrammatic test items was recorded. In the same way, note was made of the time taken to prepare quality assured objective test items (Table 76; p 403).

4.21 Time taken to grade and record results by traditional methods
For comparative purposes, the time spent by experienced academic staff to grade and mark two-hour examination papers was recorded. These data were converted to a standard ratio of academic staff hours to grade a two-hour written examination by 100 students (Table 76).

4.22 Time saved to access and grade computerized results
Using SOCCER, measurements were applied to assess the time taken by 100 students during diagrammatic challenge tests with a further 100 MCQ test questions. Note was taken of the time required to retrieve and collate these results at the end of a formal examination session. For detailed information, please refer to Table 76.

4.23 Consumable costs of traditional methods
Estimates were made of sundry items used in a traditional scenario, such as the provision of photo-copied materials, lecture notes, hand outs, study directives, examination papers, invigilation and examination booklets (see Table 76).
4.24 Consumable costs saved by computerized learning and testing
Note was taken of items saved by the introduction of learning and testing in anatomy and pathology via SOCCER (Table 76). Apart from continual access to accumulated results by individual learners and academic staff, note was also taken of the administrative advantages offered by SOCCER to empower learners to print materials at their own expense.
CHAPTER 5

RESULTS AND THEIR ANALYSIS

As described by methods in Chapter 4, the research findings of first and second year undergraduates (UG1 and UG2) were assembled from ten discrete areas of study to address the primary, secondary, and subsidiary research questions in Sections 1.1 to 1.4 (p 3) outlined in Chapter 1 of this thesis.

To resolve the primary and secondary research questions, observation of 2-D data from ten discrete areas is presented in Sections 5.1.1 to 5.1.10 (pp 267-323), followed by observation of 3-D data from three discrete areas of investigation in Sections 5.4.1 to 5.4.3 (pp 337-351).

Sufficient information is also given in Section 5.8 (p 378) to determine the effectiveness of ICALP materials to academic staff, individual students, and tertiary administrators.

Adequate quantitative and qualitative information was acquired from the feedback instrument to evaluate learner reactions throughout 1992 and 1993. This information is presented in Section 5.9 (p 407).

Coincidental to the introduction of the feedback package, unexpected information became apparent regarding the impact of pre-entry levels of knowledge of English, English Literature, Human Biology (EEHB), Mathematics, Chemistry, and Physics (MCP), which was used to address a supplementary research question in Section 5.9.2 (p 411).
5.1 Observations of 2-D experiments in ten discrete areas of study

To address the primary and first part of the secondary research questions, namely:

Can ICALP materials be effectively used to replace traditional methods when teaching anatomy to physiotherapy students?

and

Can ICALP materials be used effectively to initiate the acquisition of 2-D cognitive anatomical information?

Sufficient data were obtained by application of the ten groups of courseware listed in Section 4.12 (p 249) to compare the 2-D cognitive activities of Lecture and ICALP categories of the 1992 population. These procedures were validated by replication in 1993. As described in Sections 4.10 and 4.11 (pp 247 & 248), ANOVA, ANCOVA, and box plot results were acquired to present a uniform sequence of procedures. These data were used to provide 2-D and 3-D summaries of ICALP research in Sections 5.2 and 5.5 (pp 328 & 359) respectively.

5.1.1 Upper extremity 2-D results

The four ICALPs and two test items listed in Table 5 (p 250) in Chapter 4, were the predominant resources applied in anatomy studies of the upper extremity in 1992 and 1993. The box plot dispersions shown in Figures 120 and 121, depict pre and posttest achievements by the Lecture and ICALP groups in 1992 and 1993. Although statistically insignificant in this instance, at first glance there appears to be a slight advantage to the Lecture group in both cases. With the exception of outliers, inspection of pretest values in Figure 120, reveals an asymmetric distribution from the Lecture group compared with a more symmetric distribution by the ICALP group in 1992.
Furthermore, at pretest, Figure 120 presents the Lecture group with an uneven distribution, whereas, with the exception of outliers, the arrangement of the ICALP group is evenly spread.

The posttest achievements of the 1992 population in Figure 120 are of interest. The Lecture group shows a more symmetric arrangement in comparison with the ICALP group, which shows a slightly uneven distribution and one outlier at the end of each whisker.

Although different in structure, the results in Figure 121 for 1993 are comparable to the 1992 achievements in Figure 120. However, in Figure 121 the Lecture group appears to possess a slight advantage of test results. Nevertheless, with a more widely spread box, the ICALP group shows a more even distribution, with one outlier showing an inexplicable score of 37.9%. In every other respect, the posttest efforts of the 1993 population are satisfactory for this complex area of study.
To enable further comparison of 2-D of upper extremity experiments, Tables 11 and 12 were applied to the 1992 population, and Tables 13 and 14 to the 1993 population.

**Table 11. Upper extremity pretest 1992.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
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<td>ICALP</td>
<td>39</td>
<td>34.59</td>
<td>8.17</td>
<td>1</td>
<td>28.093</td>
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<tr>
<td>Lecture</td>
<td>40</td>
<td>35.78</td>
<td>8.54</td>
<td>77</td>
<td>5383.534</td>
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</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- 0.140</td>
<td>0.005</td>
<td>F = 0.402</td>
</tr>
</tbody>
</table>

The pretest mean in Table 11 confirms a slight advantage of 35.78% to the Lecture group against the score of 34.59% achieved by the ICALP
group. These data affirm those discussed from Figure 120. At posttest, a
tight formation persists in Table 12 to show the Lecture group with a
mean score of 75.56% compared with an ICALP mean of 74.03%. There
is also a tight conformity of s.d. values, with a two-point reduction at
posttest by both subgroups.

It is noteworthy that in all cases, effect sizes (ESI) were calculated by
subtraction of the mean score of the ICALP group from that of the
Lecture group, the product of which was then divided by the standard
deviation of the Lecture group. Similarly, each correlation ratio was
determined by division of ‘between’ groups with the total ‘sum of
squares’ (see Section 4.10, p 248).

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
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</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
<tr>
<td>Significance</td>
</tr>
<tr>
<td>Effect size (ESI)</td>
</tr>
<tr>
<td>Correlation ratio</td>
</tr>
<tr>
<td>Probability</td>
</tr>
</tbody>
</table>

However, the information in Tables 13 and 14 for the 1993 population is
more distinctive. Table 13 shows a four-point discrepancy in favour of
the Lecture group at pretest, with an effect size of 0.558 and correlation
ratio of 0.068. The relative differences of Table 13 are maintained in
Table 14. Although the difference between the groups is acceptable, the
increased s.d. value of 10.46 by the ICALP group confirms the box plot display in Figure 121.

### Table 13. Upper extremity pretest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>35</td>
<td>32.86</td>
<td>7.78</td>
<td>1</td>
<td>291.244</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
<td>36.86</td>
<td>7.17</td>
<td>71</td>
<td>3958.722</td>
</tr>
</tbody>
</table>

Effect size (ESI) -0.558
Correlation ratio 0.068

### Table 14. Upper extremity posttest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>35</td>
<td>71.28</td>
<td>10.46</td>
<td>1</td>
<td>55.897</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
<td>73.03</td>
<td>8.39</td>
<td>71</td>
<td>6325.218</td>
</tr>
</tbody>
</table>

Effect size (ESI) -0.209
Correlation ratio 0.009

### Table 13-14. ANCOVA of upper extremity pre and posttests 1993.

<table>
<thead>
<tr>
<th></th>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>Group</td>
<td>n</td>
<td>mean value</td>
</tr>
<tr>
<td>ICALP</td>
<td>35</td>
<td>32.86</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
<td>36.86</td>
</tr>
</tbody>
</table>
The magnitude of pre and posttest differences suggested by analysis of covariance in Table 13-14, produced adjusted mean values mildly in favour of the Lecture group in 1993.

From these variations, the change between pre and posttest, is affirmed by the convergence of results in Table 13-14. Furthermore, there is no evidence to suggest any difference of treatment between the two groups, confirmed by the data of “significance” in Table 14.

From the data provided so far, the upper extremity 2-D results tend to support the value of ICALP materials.

5.1.2 Cardiac 2-D results
Using the CardioICALP and cardio-respiratory pre and posttest items shown in Table 6 (p 250), the results of these efforts are given by ANOVA in Tables 15 to 18, by ANCOVA in Tables 15-16 and 17-18, and by box plot in Figures 122 and 123.

Comparison of the 1992 pre and posttest results in Tables 15 and 16, reveal no discordant differences in the former, with a significant advantage to the Lecture group in the latter.

At pretest, Table 15 indicates comparable mean values by the two groups, with a small advantage to the Lecture group.

At posttest, Table 16 reveals a higher achievement by the Lecture group. Table 16 shows a mildly significant correlation ratio of 0.117, together with an exceptional effect size of -0.708.
Table 15. Cardiac pretest 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>33.37</td>
<td>6.59</td>
<td>1</td>
<td>21.925</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>34.43</td>
<td>8.74</td>
<td>77</td>
<td>4601.845</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- 0.121</td>
<td>0.005</td>
<td>$F = 0.367$ $P = 0.546$</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>83.35</td>
<td>5.56</td>
<td>1</td>
<td>324.318</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>87.40</td>
<td>5.72</td>
<td>77</td>
<td>2450.759</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- 0.708</td>
<td>0.117</td>
<td>$F = 10.190$ $P = 0.002$</td>
</tr>
</tbody>
</table>

To enable additional analysis of the 1992 and 1993 cardiac results, regression strategies were applied to compare the mean pretest and unadjusted posttest values with their adjusted outcomes by ANCOVA in Table 15-16.
Table 15-16. ANCOVA of cardiac pre and posttests 1992.

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
</tr>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>ICALP</td>
<td>40</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
</tr>
</tbody>
</table>

In the case of the 1992 population, Table 15-16 gives an overall advantage to the Lecture group. Strikingly, the inter-group difference of 1.06 at pretest gave an unadjusted gap of 4.05, converging to an adjusted gap of 3.72 in favour of the Lecture group at posttest in 1992. At pretest, Table 17 indicates a slight advantage to the ICALP group when compared with the Lecture group in 1993. However, the remaining data in Table 17 appears to be of no other significance.

Table 17. Cardiac pretest 1993.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
</tr>
<tr>
<td>ICALP</td>
<td>37</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
</tr>
</tbody>
</table>

| Significance      |                      |
| Effect size (ESI) | 0.041                |
| Correlation ratio | 0.021                |
| Probability       | F = 1.522, P = 0.221 |

At first glance, the data in Table 18 appears to place the ICALP group mildly ahead of its Lecture counterpart. However, this is not fully sustained when Table 18 is viewed by box plot in Figure 123.
With due consideration to the adverse effect of outliers in each group, the uniformity of box and whiskers is in favour of the Lecture group in 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>81.95</td>
<td>7.84</td>
<td>1</td>
<td>56.496</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>80.19</td>
<td>7.39</td>
<td>71</td>
<td>4127.091</td>
</tr>
</tbody>
</table>

**Significance**

<table>
<thead>
<tr>
<th>Effect size (ESI)</th>
<th>0.022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>0.013</td>
</tr>
<tr>
<td>Probability</td>
<td>( F = 0.972 ) ( P = 0.328 )</td>
</tr>
</tbody>
</table>

Table 18. Cardiac posttest 1993.

Table 17-18. ANCOVA of cardiac pre and posttests 1993.

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
</tr>
<tr>
<td></td>
<td>( n )</td>
</tr>
<tr>
<td>Group</td>
<td></td>
</tr>
<tr>
<td>ICALP</td>
<td>37</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 17-18 shows a pretest difference of 1.81 in favour of the ICALP group, reduced to an unadjusted difference of 1.76 in favour of the Lecture group at posttest in 1993. Furthermore, the adjusted scores of the ICALP and Lecture groups, show a reversed gap of 0.92 in favour of the Lecture group. The 1992 position in Table 15-16 is condensed by the population of 1993 in Table 17-18, by a reversal of discrepancy between the adjusted and unadjusted scores of both groups.
These data are confirmed by box plot in Figure 122. Apart from a wide box and whisker distribution from the Lecture group at pretest, with the exception of a single outlier at 65, the posttest result of the Lecture group in Figure 122 is admirable.

Although the general level of achievement in cardiology by the ICALP group in 1992 is satisfactory, its posttest distribution in Figure 122 confirms the discordant values of significance revealed in Table 16. This is evidenced by a compact box and asymmetric distribution around the median, with four outliers outside the lower whisker.

In 1993, the box plots in Figure 123 are more definitive. With the exception of extraneous outliers, the general formation of box and whiskers is comparable throughout cardiac studies at that time.
However, when the findings of cardiac studies in 1992 and 1993 are evaluated overall, there is marginal evidence which favours Lecture groups for the presentation of 2-D information to undergraduate anatomists.

5.1.3 Respiratory 2-D results
The Respiratory ICALP and pre-posttest items in Table 6 (p 250) were used by the UG2 populations in 1992 and 1993. Acquired information from these resources provided mean and ANOVA values in Tables 19 to 22, by ANCOVA in Tables 19-20 and 21-22, and by box plot in Figures 124 and 125.

Comparison of respiratory pre and posttest results in 1992, Tables 19 and 20 show no meaningful differences in the former, with a five-point advantage to the Lecture group in the latter. At pretest, the mean values of the two groups demonstrate a 1.38 difference in favour of the Lecture
group. At posttest, the Lecture group achieved a mean value of 79.36% compared with 75.08% acquired by the ICALP group.


<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>33.37</td>
<td>7.84</td>
<td>1</td>
<td>38.385</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>34.75</td>
<td>7.39</td>
<td>77</td>
<td>4064.298</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.188</td>
<td>0.009</td>
<td></td>
</tr>
</tbody>
</table>

Although the posttest results for this segment are satisfactory in Table 20, the effect size of -0.733 and correlation ratio of 0.117 appear to be of some significance.


<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>75.08</td>
<td>6.07</td>
<td>1</td>
<td>362.424</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>79.36</td>
<td>5.85</td>
<td>77</td>
<td>2734.034</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.733</td>
<td>0.117</td>
<td></td>
</tr>
</tbody>
</table>

|            | F = 10.207       | P = 0.002        |             |
To generate further analysis of the data from the 1992 respiratory results, regression strategies were applied to compare pre and posttest values to determine the adjusted outcomes shown in Table 19-20. In the case of the 1992 population, an overall mean of 34.05% was calculated at pretest. Furthermore, the unadjusted difference of 1.38 at pretest was increased to 4.28 at posttest, but reduced to an adjusted gap of 3.92, with a minor advantage to the Lecture group.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>mean value</th>
<th>Pretest</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>adjusted</td>
<td>unadjusted</td>
</tr>
<tr>
<td>ICALP</td>
<td>40</td>
<td>33.37</td>
<td>75.23</td>
<td>75.08</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>34.75</td>
<td>79.15</td>
<td>79.36</td>
</tr>
</tbody>
</table>

At pretest, the 1993 results in Table 21 show a 2.07 point advantage to the Lecture group. Apart from an effect size of -0.323, the remaining data in Table 21 indicates no other significant differences.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>35</td>
<td>42.61</td>
<td>5.93</td>
<td>1</td>
<td>77.665</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
<td>44.68</td>
<td>6.38</td>
<td>71</td>
<td>2704.986</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>-0.323</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>Probability</td>
<td>$F = 2.039$</td>
<td>$P = 0.158$</td>
</tr>
</tbody>
</table>
The minor disparities in Table 21 at pretest are sustained at posttest in Table 22, with insignificant mean differences of 2.07 and 2.38 marginally in favour of the Lecture group.

<table>
<thead>
<tr>
<th>Table 22. Respiratory posttest 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

By ANCOVA in Table 21-22, the adjusted scores of the respiratory population in 1993, moved to 72.95% and 75.36% for the ICALP and Lecture groups respectively, showing a margin of 2.41 in favour of the Lecture group.

<table>
<thead>
<tr>
<th>Table 21-22. ANCOVA of respiratory pre and posttests 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control-variable</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

However, when viewed by box plot in Figure 124, the range of variation is more evenly distributed in the ICALP group than its Lecture counterpart. With the exception of one outlier below the whisker of the
Lecture group, all four boxes in Figure 124 reveal a symmetric progression of pre and posttest values. Furthermore, although Figure 124 affirms that the ICALP group started at a lower level, the homogeneity of both groups is sustained at posttest.

![Box plot](image)

**Figure 124. Respiratory pre-posttests 1992.**

Nevertheless, the level of differences shown by box plot in Figure 124 do not explain the effect size of -0.733 displayed in Table 20. These discrepancies become more transparent when Table 22 is compared by box plot with Figure 125. It is of interest to note that of the two outliers below the lower whisker of the ICALP group at pretest, one individual managed to join the box at its median whilst the other remained below the whisker at posttest. In the case of the Lecture group, the individual identified as an outlier below the lower whisker at pretest is the same one presented at posttest.
It is also worthy of note, when comparing the box plots in Figure 125, that the dispersion of the ICALP group at pretest is not sustained at posttest. Apart from the 2.38 disadvantage to the ICALP group, there is a remarkable concordance of presentation by box and median from both groups at posttest for respiratory studies in 1993.

From these results, together with evidence of low probability values, correlational ratios, and box plots, the widened s.d. values in Table 22 combined with other analytical data, suggest a minor advantage to the Lecture group during respiratory studies in 1992 and 1993.

5.1.4 CTRS 2-D results

The software listed in Table 6 (p 250) provided the core of 2-D studies of the cardio-thoracic respiratory system (CTRS) by the 1992 and 1993 populations. The database from these instruments was used to construct the mean values shown in Figures 126 and 127. The same database was
used by box plot to compare the achievements of the ICALP and Lecture groups in Figures 128 and 129. These data are also illustrated in Tables 23 to 26, and Tables 23-24 and 25-26.

Figure 126. Comparison of 2-D CTRS scores in 1992.

Figures 126 and 127 provide comparative 2-D achievements of the ICALP and Lecture groups during CTRS studies in 1992 and 1993.

Clearly there is no difference in either population at pretest, with evidence in favour of the ICALP group at posttest in 1992. At posttest in 1993, Figure 127 shows a reversal of the position of ICALP and Lecture groups, with a fractional advantage to the latter.
At pretest for CTRS studies in 1992, Table 23 demonstrates a close proximity of results, supported by a low effect size and correlation ratio, showing a minor advantage to the ICALP group.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>ICALP</td>
<td>40</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
</tr>
<tr>
<td>Significance</td>
<td>Effect size (ESI)</td>
</tr>
<tr>
<td></td>
<td>Correlation ratio</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
</tr>
</tbody>
</table>
At posttest for CTRS studies in 1992, Table 24 shows mean values which illustrate an advantage to the ICALP group, supported by an increased effect size and raised correlation ratio.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>79.40</td>
<td>5.77</td>
<td>1</td>
<td>394.876</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>74.92</td>
<td>6.06</td>
<td>77</td>
<td>2698.739</td>
</tr>
</tbody>
</table>

**Table 24. Cardio-Thoracic Respiratory System 2-D posttest 1992.**

**Means table**

**Analysis of variance**

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.739</td>
<td>0.127</td>
<td>F = 11.267  P = 0.001</td>
</tr>
</tbody>
</table>

**Table 23-24. ANCOVA of CTRS 2-D pre and posttests 1992.**

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>adjusted</td>
<td>unadjusted</td>
</tr>
<tr>
<td>Group</td>
<td>n</td>
<td>mean value</td>
<td></td>
</tr>
<tr>
<td>ICALP</td>
<td>40</td>
<td>34.75</td>
<td>78.92</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>33.37</td>
<td>75.15</td>
</tr>
</tbody>
</table>

To clarify the matter further, adjusted means were derived by ANCOVA to compare these values in Table 23-24. Scrutiny of the former results show an inter-group gap of 1.38 in favour of the ICALP group at pretest. At posttest, the unadjusted scores show an advantage of 4.48 to the ICALP group, reduced to an adjusted gap of 3.77. Notwithstanding the convergence of unadjusted-adjusted scores, these data favour the ICALP group for CTRS studies in 1992.
From CTRS pretest studies in 1993, Table 25 reveals a narrow proximity of results, supported by a minimal effect size and correlation ratio, with a fractional advantage to the ICALP group.

**Table 25.** Cardio-Thoracic Respiratory System 2-D pretest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>43.85</td>
<td>6.43</td>
<td>1</td>
<td>2.818</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>43.46</td>
<td>6.05</td>
<td>71</td>
<td>2767.520</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.064</td>
<td>0.001</td>
<td>F = 0.072</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P = 0.788</td>
</tr>
</tbody>
</table>

At posttest, Table 26 shows mean values, with a slight elevation and reversal of effect size, countered by a low correlation ratio. Nevertheless, these results show a marginal advantage to the Lecture group.

**Table 26.** Cardio-Thoracic Respiratory System 2-D posttest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>80.21</td>
<td>8.04</td>
<td>1</td>
<td>56.477</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>81.98</td>
<td>7.18</td>
<td>71</td>
<td>4127.139</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.246</td>
<td>0.013</td>
<td>F = 0.971</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P = 0.328</td>
</tr>
</tbody>
</table>
Observation of results in Table 25-26 show a gap of 0.39 at pretest, increased to an unadjusted gap of 1.77 and an adjusted gap of 2.12 to favour the Lecture group in 1993.

When viewed by box plot, with the exception of one outlier below the posttest ICALP results in Figure 128, there is a remarkable uniformity in all components which affirm an advantage to the ICALP group in 1992.
However, this is not the case in 1993. Pretest results in Figure 129 show both groups to be evenly matched, each with one outlier equidistant below the lower whisker. Although the median strip of the Lecture group at pretest in Figure 129 coincides with the pretest mean of 43.46% in Table 25, the three outliers below the lower whisker at posttest contravene an otherwise even distribution of data. Of further interest, is that the distribution of 2-D pretest results exhibited by the ICALP group in Figure 129, is repeated at posttest, with a marginal spread overall, showing the same individual as an outlier in both instances below the lower whisker.

![Box plot](image)

**Figure 129. Cardio-Thoracic Respiratory System pre-posttests 1993.**

Nevertheless, although the pretest ICALP mean in Table 25 appears to coincide with the median in Figure 129, this is not the case at posttest, where Table 26 shows a mean below the median exhibited at the centre of the box in Figure 129.
From the CTRS research findings, there is clear evidence in favour of the ICALP group in 1992, followed by parity between the two groups in 1993.

5.1.5 Lower extremity 2-D results
The ICALP and test items listed in Table 7 (p 251) were used as source materials for the lower extremity experiments. From these items, specific software was applied to determine 2-D results achieved by the UG1 population in 1992 (Figure 130). The same software was re-applied to the same population as UG2 students in 1993 (Figure 131). These results are verified for both populations by ANOVA in Tables 27 to 30, and ANCOVA for the 1992 and 1993 populations in Tables 27-28 and 29-30. These data are explored further by box plot in Figures 132 and 133.

![Figure 130. Lower extremity 2-D pre and posttest scores achieved by UG1 students in 1992.](image)
Comparison of the concurrent achievements of the UG1-UG2 research population during its progression in 2-D studies of the lower extremity in Figures 130 and 131, show a remarkable uniformity of effort. Despite an increased standing in 1993, there are no other observable differences of distribution between the ICALP and Lecture groups throughout.

Figure 131. Lower extremity 2-D pre and posttest scores achieved by UG2 students in 1993.

These data are verified by ANOVA in Tables 27 and 28 for the 1992 population, and in Tables 29 and 30 for the same population in 1993.

At pretest in 1992, Table 27 indicates no observable differences, with a minor advantage to the Lecture group and a slightly elevated effect size.
Table 27. Lower extremity 2-D pretest scores of 1st years 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>36</td>
<td>45.50</td>
<td>8.00</td>
<td>1</td>
<td>79.030</td>
</tr>
<tr>
<td>Lecture</td>
<td>37</td>
<td>47.58</td>
<td>7.59</td>
<td>71</td>
<td>4318.252</td>
</tr>
</tbody>
</table>

Significance

| Effect size (ESI) | - 0.274 |
| Correlation ratio | 0.018 |
| Probability       | \( F = 1.299 \)  \( P = 0.258 \) |

However, at posttest in 1992, Table 28 illustrates an advantage to the ICALP group, accompanied by a slight elevation of effect size, but virtually no change in correlation ratio.

Table 28. Lower extremity 2-D posttest scores of 1st years 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>36</td>
<td>65.55</td>
<td>7.09</td>
<td>1</td>
<td>59.386</td>
</tr>
<tr>
<td>Lecture</td>
<td>37</td>
<td>63.75</td>
<td>5.92</td>
<td>71</td>
<td>3021.062</td>
</tr>
</tbody>
</table>

Significance

| Effect size (ESI) | 0.305 |
| Correlation ratio | 0.019 |
| Probability       | \( F = 1.396 \)  \( P = 0.241 \) |

To investigate the matter further, regression analyses were undertaken to compare pretests with unadjusted and adjusted posttest scores in 1992. These data, in Table 27-28, show a discrepancy of 2.08 points in favour
of the Lecture group at pretest, later reversed to a 1.8 unadjusted advantage, marginally expanded to a 2.62 adjusted advantage to the ICALP group. Apart from a deficit of 0.62 between unadjusted and adjusted scores of the Lecture group, from these findings there appears to be no disadvantage to either group during UG1 ICALP studies of the lower extremity.

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control-variable</strong></td>
</tr>
<tr>
<td><strong>Pretest</strong></td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

At the UG2 level, Table 29 shows a distinctive advantage to the Lecture group at pretest, with an elevated effect size of -0.549.

<table>
<thead>
<tr>
<th>Table 29. Lower extremity pretest scores of 2nd years 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- 0.549</td>
<td>0.088</td>
<td>F = 6.844</td>
</tr>
</tbody>
</table>

|                      | P = 0.011        |

However, the findings at pretest in Table 29 were reversed at posttest by the UG2 population in Table 30. In the latter case, there is an observable
advantage to the ICALP group, with a marked reduction of effect size and correlation ratio.

Table 30. Lower extremity posttest scores of 2nd years 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{x} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>35</td>
<td>73.64</td>
<td>7.63</td>
<td>1</td>
<td>24.998</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
<td>72.47</td>
<td>8.64</td>
<td>71</td>
<td>4737.067</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect size (ESI)</td>
<td>0.135</td>
</tr>
<tr>
<td>Correlation ratio</td>
<td>0.005</td>
</tr>
<tr>
<td>Probability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( F = 0.375 )</td>
</tr>
<tr>
<td></td>
<td>( P = 0.542 )</td>
</tr>
</tbody>
</table>

The 2-D results of the 1993 population in Figure 131 and Tables 29 and 30, although not statistically significant, provide evidence in support of ICALP learning for the lower extremity.

Table 29-30. ANCOVA of lower extremity 2-D pre and posttests 1993.

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
</tr>
<tr>
<td></td>
<td>n</td>
</tr>
<tr>
<td>Group</td>
<td></td>
</tr>
<tr>
<td>ICALP</td>
<td>35</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
</tr>
</tbody>
</table>

Although the UG2 population demonstrate some difficulties at pretest in Table 29, at posttest, the effect size of 0.135 and correlation ratio of 0.005 in Table 30 suggest an advantage to the ICALP group. These observations are supported by ANCOVA in Table 29-30. The foregoing information is clarified by box plot in Figures 132 and 133.
Although the UG1 ICALP results in Figure 132 are marginally higher than those of the Lecture group, with the exception of one outlier above the ICALP group, there is a uniform distribution at posttest in both cases.
The same conformity by box plot in Figure 133 may be used to explain the achievements of the UG2 population in 1993. At pretest, the 2-D ability of the Lecture group is seen to pre-empt that of the ICALP group, with the exception of a single outlier above the upper whisker. At posttest, the Lecture group has moved up in much the same format, leaving two outliers behind. However, this is not the case with the ICALP group, which shows a uniform elevation at posttest, displaced by a median strip above the middle of the box.

From these data, there appears to be sufficient evidence to support the use of ICALP methods to dispense 2-D anatomical information to undergraduates in studies of the lower extremity.

5.1.6 CNS 2-D results

The seven ICALP and pre-posttest items in Table 8 (p 251) were applied as learning and test resources for the CNS component of this project in 1992 and 1993. The conditions of 2-D experiments applied to CTRS and lower extremity experiments in Sections 5.1.4 and 5.1.5 respectively during 1992 and 1993, were extended in CNS studies during the same periods to investigate the effect of unexpected re-testing at 60 and 120 day intervals after the original posttest. The results of these experiments are shown in Figures 134 and 135, by box plot in Figures 136 and 137, and by ANOVA and ANCOVA in Tables 31 to 38. These data may be compared with styles of learning and revision in Table 73-4 (p 372) and review of results in Tables 55-1 and 55-2 (pp 330 & 331) Furthermore, CNS studies were linked to the problem-based learning strategies described in Sections 3.40, 3.41, and 4.14 (pp 231, 232, & 259).
When compared, important observations may be made about the pre, post, and re-test results in Figures 134 and 135.

![Bar Chart](chart.png)

**Figure 134.** C.N.S. 2-D pre and posttest results with 60 and 120 day re-test scores achieved by UG2 in 1992.

Firstly, from Figure 134, it may be noted that the 1992 population was observed to be highly motivated by the CNS 2-D study.

Secondly, with the exception of minor variations, Figure 135 shows that both categories maintained the same configuration of test and re-test results shown by their predecessors in 1992.

Finally, it is important to note that the mild pre-eminent relationship of the ICALP group over the Lecture group is sustained in all experiments represented in Figures 134 and 135.
Figure 135. C.N.S. 2-D pre and posttest results with 60 and 120 day re-test scores achieved by UG2 in 1993.

These data are affirmed by comparison of group differences with Tables 31 to 38.

Table 31. CNS 2-D pretest scores 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>39</td>
<td>47.26</td>
<td>7.89</td>
<td>1</td>
<td>6.675</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>46.67</td>
<td>10.74</td>
<td>77</td>
<td>6872.211</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect size (ESI)</td>
<td>0.055</td>
</tr>
<tr>
<td>Correlation ratio</td>
<td>0.001</td>
</tr>
<tr>
<td>Probability</td>
<td>F = 0.075 P = 0.785</td>
</tr>
</tbody>
</table>
The 1992 population in Table 31 demonstrate unusually advanced pretest levels of 47.26% for the ICALP group and 46.67% for the Lecture group. The standard deviation of the Lecture group in Table 31 confirms the extended box plot in Figure 136.

However, at posttest, Table 32 shows improved mean scores for both research groups in 1992, accompanied by an elevation of effect size and correlation ratio, giving an observable advantage to the ICALP group.

<table>
<thead>
<tr>
<th>Table 32. CNS 2-D posttest scores 1992.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
</tr>
<tr>
<td>Effect size (ESI)</td>
</tr>
<tr>
<td>Correlation ratio</td>
</tr>
<tr>
<td>Probability</td>
</tr>
</tbody>
</table>

The fractional decay of retained 2-D information by the 1992 population in Figure 134, is not evident in the pattern of CNS results obtained in 1993, as shown by Figure 135. Instead, there is a remarkable uniformity of achievement throughout the experimental period.

From this, with the exclusion of any other qualitative differences between 1992 and 1993, there is a distinct conformity of retained information by both cohorts throughout each test period.

298
To investigate observed differences between Tables 31 and 32, a regression procedure was undertaken, as seen in Table 31-32.

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
</tr>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>ICALP</td>
<td>39</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
</tr>
</tbody>
</table>

Of interest, is that the pretest advantage of the ICALP group in 1992, was initially retained by unadjusted scores, but reversed to advantage the Lecture group in Table 31-32.

Table 33 illustrates the responses of the 1992 CNS population to an unexpected re-appearance of the 2-D test following a 60 Day interval.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td></td>
</tr>
<tr>
<td>ICALP</td>
<td>39</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>( \bar{X} )</td>
</tr>
<tr>
<td></td>
<td>70.79</td>
</tr>
<tr>
<td></td>
<td>67.85</td>
</tr>
<tr>
<td></td>
<td>9.56</td>
</tr>
<tr>
<td></td>
<td>8.50</td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>df</td>
</tr>
<tr>
<td></td>
<td>Sum of Squares</td>
</tr>
<tr>
<td>ICALP</td>
<td>1</td>
</tr>
<tr>
<td>Lecture</td>
<td>171.533</td>
</tr>
<tr>
<td></td>
<td>6296.767</td>
</tr>
<tr>
<td>Significance</td>
<td>Effect size (ESI)</td>
</tr>
<tr>
<td></td>
<td>0.346</td>
</tr>
<tr>
<td></td>
<td>Correlation ratio</td>
</tr>
<tr>
<td></td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
</tr>
<tr>
<td></td>
<td>F = 2.098 P = 0.152</td>
</tr>
</tbody>
</table>

As may be seen by comparison with Table 32 and Figure 134 with Table 34 at the 60 day re-test, there is a certain uniformity of effect size and
correlation ratio. Furthermore, apart from a visible decay in the retention of knowledge by both groups, the ICALP group maintained the same advantage over its Lecture counterpart.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>39</td>
<td>70.04</td>
<td>8.93</td>
<td>1</td>
<td>91.356</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>67.88</td>
<td>8.28</td>
<td>77</td>
<td>5701.321</td>
</tr>
</tbody>
</table>

Effect size (ESI) 0.261
Correlation ratio 0.016
Probability \( F = 1.234 \) \( p = 0.270 \)

For additional verification, the same test was unexpectedly applied after a delay of 120 days. In this case, Table 34 affirms no decay in the retention of 2-D CNS knowledge by either group, with a minor reduction of effect size and correlation ratio. As shown in Figure 134, the ICALP group sustained the same level of advantage over its Lecture counterpart at posttest and throughout the 60 and 120 day re-tests.

To validate the 1992 findings of 2-D experiments in CNS studies, the whole sequence was replicated, without prior announcement, to the 1993 population. These results are given in Table 35 to 38.

As may be seen in Figure 135, Table 35 displays an expected level of inexperience in CNS matters at pretest by the 1993 UG2 population.
Apart from a low pretest achievement, there is a remarkable uniformity among the two subgroups in Table 35.

<table>
<thead>
<tr>
<th>Table 35. CNS 2-D pretest scores 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Significance</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effect size (ESI)</strong></td>
<td>0.114</td>
</tr>
<tr>
<td><strong>Correlation ratio</strong></td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>F = 0.218 P = 0.642</td>
</tr>
</tbody>
</table>

At posttest, Table 36 confirms the mean values displayed in Figure 135. In this situation, the ICALP group demonstrated an identical pre-eminence over the Lecture group, which was the case presented by their predecessors in 1992 (For comparison, see Table 32 and Figure 134).

<table>
<thead>
<tr>
<th>Table 36. CNS 2-D posttest scores 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Significance</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effect size (ESI)</strong></td>
<td>0.242</td>
</tr>
<tr>
<td><strong>Correlation ratio</strong></td>
<td>0.013</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>F = 0.935 P = 0.337</td>
</tr>
</tbody>
</table>
Regression analyses were applied to identify any differences between the results in Tables 35 and 36. The differences illustrated in Table 35-36 show a convergence of unadjusted and adjusted scores, with an advantage to the ICALP group during the 2-D CNS experiments in 1993.

<table>
<thead>
<tr>
<th>Table 35-36. ANCOVA of CNS 2-D pre and posttests 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control-variable</td>
</tr>
<tr>
<td>Pretest</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

As in 1992, the same CNS test was unexpectedly re-applied at 60 and 120 day intervals, the results of which are given in Tables 37 and 38 respectively.

<table>
<thead>
<tr>
<th>Table 37. CNS unexpected 60 day re-test scores 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means table</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>0.163</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation ratio</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
<td>( F = 0.308 ) ( P = 0.580 )</td>
</tr>
</tbody>
</table>

Strikingly, the pattern of performance shown by the two research categories of the 1992 population in Figure 134, were repeated by their
successors in Figure 135, during the replication of CNS experiments in 1993.

This may be confirmed by comparison of Tables 37 and 38 with Figure 135. Furthermore, Table 38 shows a fractional increase in the level achieved by the ICALP group, and a comparable decrease by the Lecture group.

These data again confirm the value of ICALP materials to dispense anatomical material to undergraduate students.

<table>
<thead>
<tr>
<th>Table 38. CNS unexpected 120 day re-test scores 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td><strong>Analysis of variance</strong></td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
</tr>
<tr>
<td>Effect size (ESI)</td>
</tr>
<tr>
<td>Correlation ratio</td>
</tr>
<tr>
<td>Probability</td>
</tr>
</tbody>
</table>

Nevertheless, more explicit information may be discerned by box plot from Figures 136 and 137. At pretest, there is considerable variation in the quality of performance between the two subgroups in Figure 136, with an advantage to the ICALP group.

However, this information is not detectable in Figure 134. At posttest in 1992, Figure 136 demonstrates a compression of box and whiskers by
the Lecture group, pre-empted by an evenly distributed ICALP group, off-set by one outlier below the lower whisker.

In 1993, with the exception of one outlier above the whisker of the ICALP group, Figure 137 shows a compression of both groups in the 2-D pretest of 1993.

Furthermore, at posttest, there is a more even distribution of box and whiskers by the Lecture group when compared to the ICALP group, which shows a longer upper whisker.

Figure 136. CNS 2-D pre-posttests 1992.
It is of prime importance to note that the dissemination of anatomical information about the CNS in the physiotherapy syllabus is arranged to precede its content in parallel professional subjects to potentiate mutual reinforcement. The relevance of such reinforcement is already evident from analysis of Respiratory and CTRS results in Sections 5.1.3 and 5.1.4, supported by scrutiny of the time spent in revision by participants of the CNS, CeBar, EmbPNS, SFDPN, and Reflex topics shown in Tables 73-4, 73-5 and 73-6 respectively (pp 372, 375 & 377).

Notwithstanding the above comments, the overall findings in this section, support the implementation of ICALP materials to present 2-D neuro-anatomical information to undergraduate students.

5.1.7 Cerebellar 2-D results
Although 3-D laboratory specimens and Problem-based strategies were incorporated, cerebellar (CeBar) studies in 1992 and 1993 were confined
to the 2-D ICALP and Lecture style of presentation already described, varied by an option of self-selection in 1993.

The 1992 population was randomly subdivided into ICALP and Lecture groups of n=39 and n=40 respectively, whereas only seven subjects of the 1993 population selected the Lecture option, leaving the remaining 66 with an ICALP preference. From this, it is evident that during the CeBar studies of 1992, the groups were defined by the researcher, whereas in the replicated study of 1993, sixty-six of the participants selected the ICALP option. This information is considered to be highly significant in favour of a self-selection approach to ICALP learning.

Notwithstanding the prior rate of success in CNS studies described in Section 5.1.6, study of the CeBar system is a formidable task. To meet this requirement, two CeBar ICALPs were developed, one to investigate structure, the other to explore its patho-physiology of function linked to dysfunctional episodes.

The CeBar and test resources are listed in Table 8 (p 251). The energies of CeBar learning, revision, and testing are shown in Table 73-4 (p 372), the results of which may be reviewed in Table 55-1 (p 330).

Comparative data are given in Figures 138 and 139, by box plot in Figures 139 and 141, and by ANOVA in Tables 39 to 42.

Inspection of the pre and posttest results obtained in CeBar studies by the 1992 and 1993 populations are presented in Figure 138 and 139 respectively.
Figure 138. Pre and posttest results of Lecture and ICALP groups during studies of the structure, function and dysfunction of the cerebellum in 1992.

Overall, Figure 138 presents equal mean scores at pretest, with a small advantage to the ICALP group at posttest in 1992, with a marginal shift in Figure 139 to favour the Lecture group in 1993.

Figure 139 affirms the value of the self-selection option chosen by 66 students in 1993 to study the CeBar materials by ICALP alone, whereas seven students elected to receive the same information by lecture.
Figure 139. Pre and posttest results of lecture and ICALP self-selected groups during studies of the structure, function and dysfunction of the cerebellum in 1993.


<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>39</td>
<td>20.60</td>
<td>2.32</td>
<td>1</td>
<td>5.616</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>21.13</td>
<td>2.10</td>
<td>77</td>
<td>550.322</td>
</tr>
</tbody>
</table>

Significance

| Effect size (ESI)   | - 0.252 |
| Correlation ratio   | 0.010   |
| Probability         | $F = 0.786$, $P = 0.378$ |
Apart from an elevation of effect size, and minor advantage to the Lecture group, Table 39 reveals no discernible differences between the two study groups at CeBar pretest in 1992.

However, at posttest, Table 40 reveals a marked advantage to the ICALP group, accompanied by an effect size of 0.463.

**Table 40. Cerebellar posttest 1992.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\tilde{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>39</td>
<td>74.88</td>
<td>8.25</td>
<td>1</td>
<td>345.363</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>70.70</td>
<td>9.02</td>
<td>77</td>
<td>5763.477</td>
</tr>
</tbody>
</table>

**Significance**

- Effect size (ESI) 0.463
- Correlation ratio 0.056
- Probability $F = 4.614$  $P = 0.035$

**Table 41. Cerebellar (66 subjects self-directed) pretest 1993.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\tilde{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>66</td>
<td>20.67</td>
<td>2.74</td>
<td>1</td>
<td>0.89</td>
</tr>
<tr>
<td>Lecture</td>
<td>7</td>
<td>21.04</td>
<td>2.17</td>
<td>71</td>
<td>516.179</td>
</tr>
</tbody>
</table>

**Significance**

- Effect size (ESI) -0.170
- Correlation ratio 0.002
- Probability $F = 0.123$  $P = 0.727$
The pre and posttest results of 1992 were validated by the replicated findings from CeBar experiments in Tables 41 and 42 during 1993.

The pretest findings in Table 41 are almost a carbon copy of those derived from the previous cohort in Table 39.

Table 42. Cerebellar (66 subjects self-directed) posttest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>66</td>
<td>78.31</td>
<td>9.01</td>
<td>1</td>
<td>1.525</td>
</tr>
<tr>
<td>Lecture</td>
<td>7</td>
<td>78.80</td>
<td>8.36</td>
<td>71</td>
<td>5697.995</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- 0.059</td>
<td>0.000</td>
<td>F = 0.019   P = 0.890</td>
</tr>
</tbody>
</table>

Surprisingly, the results outlined in Table 42 illustrate a competitive achievement by both subgroups, with a fractional advantage to the self-selected Lecture group. The results of Tables 41 and 42, not only demonstrate the capacity of ICALP participants to reach the same level of achievement as their Lecture counterpart in a complex subject, but also serves to demonstrate a ratio of willingness to tackle the topic independently by computer alone.

Despite the self-selection option in 1993, at pretest, all four research categories of both populations were well matched, confirmed by box plot in Figures 140 and 141. The uniformity of pretest data is not surprising, since in no case could the CeBar topic be known beforehand. From this,
it may be presumed that the pretest compression of box plots in Figures 140 and 141 present a typical profile of naivety by a group facing an unknown topic.

Conversely, none of the posttest data in Tables 40 and 42 reveal any discernible differences, a situation not sustained by box plot in Figure 141. In the latter case, at posttest, the atypical Lecture group shows a negative skewness, with a wider spread of box and whisker below the median strip. This disparity is not apparent from the ICALP plot in Figure 141, shown by an even distribution above and below the median strip.
These findings are clearly supported by Table 40 and Figure 139 for the deployment of computer-assisted learning modules for CeBar studies in 1992. Furthermore, the self-selection approach to the same ICALP materials is validated by Table 42 and Figure 140 for CeBar studies in 1993.

5.1.8 EmbPNS 2-D results
Following the success of CNS studies and self-selection approach gained from the CeBar experiments outlined in Sections 5.1.6 and 5.1.7 above, the remaining three experiments were replicated by ICALP alone. Because these components could be related to problem-based learning, studies of embryology and peripheral nervous system (EmbPNS); the structure, function, and dysfunction of peripheral nerves (SFDPN); and reflex behaviour (Reflex), they were entirely delivered in 1993 via SOCCER (self-operated computer controlled educational resource) software. The ICALP and Lecture groups of the 1992 population may be
compared with a self-directed learning style in a problem-based learning format by the 1993 population. The average test scores of 1992 and 1993 during studies of the EmbPNS are shown in Figure 142, by data in Tables 43 to 46, 55-1, 55-2, and 73-5 (313 to 314; 329 & 330; 373), and box plot in Figures 143 and 144. It is important to note that no lectures were offered for this topic in 1993, when the entire cohort studied these materials exclusively by ICALP during that period.

![Bar chart](image)

**Figure 142.** Comparative pre and posttest results of lecture and ICALP groups in 1992 during studies of embryology and the peripheral nervous system (EmbPNS).

The interest in Figure 142 is twofold. Firstly that the relative difference between the Lecture and ICALP groups of the 1992 population at pretest is maintained at posttest. Secondly, at pretest in 1993, the mean results are nearly seven points lower than those in 1992, whereas at posttest the success rate is more than two points above those of its predecessors.
Table 43. Embryology and PNS pretest 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>20.36</td>
<td>4.46</td>
<td>1</td>
<td>83.631</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>22.42</td>
<td>5.41</td>
<td>77</td>
<td>1889.633</td>
</tr>
</tbody>
</table>

Significance

- Effect size (ESI) - 0.381
- Correlation ratio 0.042
- Probability \( F = 3.408 \) \( P = 0.069 \)

Table 44. Embryology and PNS posttest 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>70.23</td>
<td>5.74</td>
<td>1</td>
<td>36.372</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>71.59</td>
<td>5.12</td>
<td>77</td>
<td>2280.188</td>
</tr>
</tbody>
</table>

Significance

- Effect size (ESI) - 0.266
- Correlation ratio 0.016
- Probability \( F = 1.228 \) \( P = 0.271 \)

Of some importance, is the lead of the Lecture group at pretest in Table 43, with an effect size of -0.381.

However, at posttest in Table 44, there is a minor reduction of relative differences between the two research groups, with a comparable decrease in effect size and correlation ratio.
Table 45. EmbPNS (self-directed ICALP learning only) pretest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>(\bar{X})</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>73</td>
<td>13.90</td>
<td>2.92</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Lecture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Significance:
- Effect size (ESI) | N/A
- Correlation ratio | N/A
- Probability      | \(F = N/A\) \(P = N/A\)

Table 46. EmbPNS (self-directed ICALP learning only) posttest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>(\bar{X})</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>73</td>
<td>74.10</td>
<td>10.09</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Lecture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Significance:
- Effect size (ESI) | N/A
- Correlation ratio | N/A
- Probability      | \(F = N/A\) \(P = N/A\)

Although the results of the EmbPNS population of 1993 in Tables 45 and 46 are comparable with those of 1992, there is a perceptible rate of success when learning by ICALP alone.
Figure 143. EmbPNS pre-posttests 1992.

Comparison of Tables 43 and 44 with the box plot formations in Figure 143, apart from one outlier at pretest, illustrate a general conformity of achievement by the EmbPNS subgroups in 1992.

Figure 144. EmbPNS pre-posttests 1993.
When the information from Tables 45 and 46 are compared by box plot in Figure 144, the compressed box and whiskers at pretest provides a further example of a uniform lack of knowledge about the topic beforehand. Nevertheless, at posttest in Table 46, there is a clear advancement with a mean score of 74.10% but wider than usual standard deviation 10.09, confirmed by Figure 144.

These data give clear support in favour of ICALP materials to effectively dispense information about embryology and peripheral nerves to undergraduate anatomy students.

5.1.9 SFDPN 2-D results

Although the structure, function, and dysfunction of peripheral nerves (SFDPN) was carried out in a normal manner during 1992, as described in Section 5.1.8, it was decided to replicate the remaining three experiments in 1993 by ICALP alone. These sections were designed to integrate problem-based learning (p 259) with episodes dispensed by SOCCER from courseware listed in Tables 8, and 9 (pp 251 to 252).

In this way, the ICALP and Lecture categories of the 1992 population enabled comparisons to be made with autonomous self-directed learning by the 1993 population. The respective results of the two populations during the studies of the structure, function, and dysfunction of peripheral nerves are given in Figure 145, supported by ANOVA in Tables 47 to 50, review of ICALP experiments in Table 73-5 (p 375), by box plot in Figures 146 and 147, and review of 2-D results for comparison with those from other topics in Tables 55-1 and 55-2 (pp 330 & 331).
When compared, the graphic profiles of the EmbPNS results in Figure 142 are almost identical with the SFDPN results in Figure 145, with a ten point elevation at pretest and matching results at posttest.

![Bar graph showing comparative results for Lectures 92, ICALP 92, and Self-directed 93 pretests and posttests.]

**Figure 145.** Comparative pre and posttest results of lecture and ICALP groups in 1992 and 1993 during studies of the structure, function and dysfunction of peripheral nerves (SFDPN).

Again it is noteworthy that, although information about the structure, function and dysfunction of peripheral nerves was conveyed to Lecture and ICALP groups in 1992, no lectures were offered for this topic in 1993. During the latter period, the entire population studied this subject by ICALP alone.

Scrutiny of Figure 145 establishes the relative difference between the Lecture and ICALP groups in 1992, which is sustained at posttest. These data may be explored in Tables 47 and 48.
At pretest in 1992, Table 47 shows the distribution of values attained by both research groups, with a minor advantage to the Lecture category.

At posttest, the data in Table 48 verifies an advantage to the Lecture group, shown by an elevated effect size of -0.523.
Comparison of the 1992 results with the effort in Tables 49 and 50, show increased values at pre and posttest in 1993.

**Table 49. SF&D of Peripheral Nerves pretest 1993.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>73</td>
<td>27.00</td>
<td>3.02</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Lecture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Significance**

<table>
<thead>
<tr>
<th>Effect size (ESI)</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>N/A</td>
</tr>
<tr>
<td>Probability</td>
<td>( F = \text{N/A} ) ( P = \text{N/A} )</td>
</tr>
</tbody>
</table>

It is of significance to note, that by ICALP alone, the population in Table 50, fractionally exceeded the achievements of the Lecture group by their predecessors in Table 48. This comparative information may be visualised in Figure 145.

**Table 50. SF&D of Peripheral Nerve posttest 1993.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>73</td>
<td>75.91</td>
<td>8.83</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Lecture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Significance**

<table>
<thead>
<tr>
<th>Effect size (ESI)</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>N/A</td>
</tr>
<tr>
<td>Probability</td>
<td>( F = \text{N/A} ) ( P = \text{N/A} )</td>
</tr>
</tbody>
</table>
These data are confirmed by box plot in Figure 147. When viewed separately, the box plot display in Figures 146 and 147 are of considerable interest. At pretest, there is mild evidence of disparity between the research categories of the 1992 population. Apart from a short upper whisker, there is considerable uniformity in the box of the Lecture group.

![Box plot](image)

Figure 146. SFDPN pre-posttests 1992.

However, this is not the case for the ICALP group, which not only demonstrates an uneven width of whiskers, but also a median strip which is located across the lower one-third of the box. At posttest, a reversal of the situation is evident in Figure 146. Although the relative sizes of the two boxes are equal, the Lecture group shows a greater spread above its median strip, a situation reversed by the ICALP group with a wider spread below the median line. Of greater importance, is the level of the median strip across the box of both groups at posttest, which show no significant differences between the two research groups in 1992.
Although no such considerations can be made about the 1993 population from Figure 147, at pretest the box and whiskers are narrow, compact and evenly distributed. At posttest, although considerably widened, the whiskers are evenly distributed, with the median strip located above the mid-line of the box. From this, it is clear that the upper 25% of the 1993 population represented by the upper whisker is slightly foreshortened, with compression of the 25% above the median in the box below it. However, the lower 50% of the population is more evenly distributed across the lower two-thirds of the box and whisker below it.

These data of 2-D studies of SFDPN resources may be verified by Tables 55-1 and 55-2 respectively (pp 330 & 331) in 1992 and 1993. Together, they affirm the effectiveness of ICALP and SOCCER to convey information to tertiary students of anatomy.
5.1.10 Reflex 2-D results

As described in Sections 5.1.8 and 5.1.9 above, the 1992 Reflex experiments were replicated in 1993 by ICALP alone. The software listed in Table 9 (p 252) was delivered to Lecture and ICALP groups in a normal way in 1992, to be contrasted by a self-directed autonomous approach via SOCCER in 1993.

In this way, the results of randomly selected ICALP and Lecture groups of the 1992 population may be compared with a self-directed, problem-based style by the 1993 population. The respective results are given in Tables 55-1, 55-2, and 73-6 (pp 330, 331, & 377), by graph in Figure 148, by ANOVA in Tables 51 to 54, and by box plot in Figures 149 and 150.

![Graph Comparative pre and posttest results of Lecture and ICALP groups in 1992 and 1993 during studies of human clinical reflex behaviour.](image-url)

*Figure 148. Comparative pre and posttest results of Lecture and ICALP groups in 1992 and 1993 during studies of human clinical reflex behaviour.*

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It is also important to note that no lectures were offered for this subject in 1993, when the entire population studied this topic by ICALP alone.

Apart from a slight advantage to the ICALP group at pretest in 1992, Figure 148 shows a lesser achievement by its self-directed successors at pretest in 1993. At posttest in 1992, Figure 148 depicts the Lecture group with a minor advantage over its ICALP counterpart. However, in 1993, although the pretest achievement of the self-directed population was below that of its predecessors, at posttest, its result was significantly increased.

The graphic display in Figure 148 may be explored by investigation of Tables 51 to 54.

|-----------------------------|

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>ICALP</td>
<td>40</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
</tr>
<tr>
<td>Significance</td>
<td>Effect size (ESI)</td>
</tr>
<tr>
<td></td>
<td>Correlation ratio</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
</tr>
</tbody>
</table>

The contents of Table 51 at pretest affirm the graphic values displayed in Figure 148. Notwithstanding the effect size of 0.335, there is a marginal advantage to the ICALP group.
Table 52. Reflex posttest 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>40</td>
<td>68.88</td>
<td>6.31</td>
<td>1</td>
<td>22.228</td>
</tr>
<tr>
<td>Lecture</td>
<td>39</td>
<td>69.93</td>
<td>7.13</td>
<td>77</td>
<td>3487.302</td>
</tr>
</tbody>
</table>

Significance

<table>
<thead>
<tr>
<th>Effect size (ESI)</th>
<th>- 0.147</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>0.006</td>
</tr>
<tr>
<td>Probability</td>
<td>F = 0.491, P = 0.486</td>
</tr>
</tbody>
</table>

At posttest in 1992, Table 52 illustrates a decrease of effect size and correlation ratio, with a minor advantage to the Lecture group. This information is substantiated by box plot in Figure 149.

Table 53. Reflex (Self-Directed) pretest 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>73</td>
<td>13.79</td>
<td>2.95</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Lecture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Significance

<table>
<thead>
<tr>
<th>Effect size (ESI)</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>N/A</td>
</tr>
<tr>
<td>Probability</td>
<td>F = N/A, P = N/A</td>
</tr>
</tbody>
</table>

The mean values of the self-directed population of 1993 are expressed in Tables 53 and 54. The main points of interest, are the narrow range at
pretest, with an advancement at posttest which exceeds the achievements of both subgroups in 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>73</td>
<td>77.13</td>
<td>8.45</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Lecture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation ratio</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
<td>F = N/A P = N/A</td>
</tr>
</tbody>
</table>

Figure 149. Reflex pre-posttests 1992.

The differences in Table 51 to 54 are explored by box plot in Figures 149 and 150. Apart from a mild displacement of the median at the lower one-
third of the box from the Lecture group in 1992, there is a remarkable uniformity of distribution exhibited by the two groups at pretest Figure 149.

However, considerable dissimilarity is found between the two groups at posttest. In this event, the box and whiskers of the Lecture group are more widely dispersed, with a shift of the median from the lower one-third of the box at pretest, to the upper one-third at posttest. With the exception of two outliers above the upper whisker, and a slightly shorter lower whisker, Figure 149 reveals a distinct uniformity at pre and posttest by the 1992 ICALP group.

![Box plot](image)

Figure 150. Reflex pre-posttests 1993.

In comparison of the box plots of the 1993 population in Figure 150, with the exception of the single outlier at the upper whisker margin at pretest, an acceptable uniformity of effort is evident at posttest, slightly off-set by a marginally elevated median and an elongated lower whisker.
When compared, there is an observable similarity of dispersion of the box plots of the 1993 population in Figures 144, 147, and 150 (pp 316, 322 & 327).

Apart from one single outlier above the whisker in Figure 150, these results coincide with the observations made about box plot profiles of naivety at pretest regarding Figure 140 in Section 5.1.7 (p 305). As stated previously, these observations may contribute to a standard pretest box plot profile of naivety on entry to an unknown academic subject.

Collectively, these research data clearly support the use of ICALP software to replace formal lectures in undergraduate studies of reflex behaviour.

5.2 Summary of 2-D ICALP experiments

When summarised for review, the resultant 2-D data presented in Sections 5.1.1 to 5.1.10, and 5.2, were applied to resolve the primary and secondary research questions of this thesis expressed in Sections 1.2 and 1.3 (p 3). From these data, comparisons were made to identify any relative differences between the research groups of the 1992 and 1993 populations. This information investigated pre and posttest information from 2-D experiments, which included mean values, standard deviations, ANOVA procedures, effect size estimators, correlation ratios, regression analyses, and box plot display.

At this stage it is considered important to revisit previous authors who applied meta-analysis techniques to standardise effect size results to determine any effects which may influence the outcome of any experimental conditions. Kulik, Kulik and Scwalb (1985), in a sample
size from two studies in adult education, found an average effect size of 1.13 in computer simulations. In five studies at the secondary school level, Kulik, Bangert and Williams (1983) were able to show an average effect size of 0.49, whereas in 10 studies at university level, Kulik and Kulik (1985) determined an average effect size of 0.36. In a comprehensive synthesis of 134 previous meta-analyses, Fraser, Walberg, Welch and Hattie (1987), determined an average effect size of 0.4 standard deviations from 7,827 studies in education. In meta-analysis of 26 educational computer simulations in 49 independent sets, McKenna (1993) found a mean effect size of 0.38. In an evaluation of the impact of computer-assisted learning (CAL) in geography by 671 second year high school students, Teh (1993) referred to an effect size average of 0.3 enunciated by Kulik and Kulik (1991). In the same style, Abik (1994) demonstrated effect size estimator averages of 0.69, 0.85, and 0.83 in three distinct areas of CAL to improve the overall academic performance of 2,187 chemistry students in 32 high school classes.

In light of the foregoing, the results of 2-D research investigations applied in this project during 1992 and 1993 are presented in Tables 55-1 and 55-2. Observation of these data are used to identify any group differences among results: namely, to account for any variation of box plot pattern; any interpretable differences in posttest mean values; any increased effect sizes above 0.30; and any correlation ratio in excess of 0.10.
<table>
<thead>
<tr>
<th>Table 55-1</th>
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<td>Table Page ICALP ICALP ICALP Lec Gp Lec Gp Lec Gp Pre ESI Post ESI Pre cor-ratio Post cor-ratio</td>
</tr>
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<td>Lower ext’y post (UG1)</td>
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<td>Reflex posttest</td>
<td>52</td>
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**Mean 2-D results 1992** | 31.96 | 73.35 | 6.16 | 6.81 | 32.50 | 73.12 | 6.45 | 6.82 | -0.092 | 0.021 | 0.013 | 0.051
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<th>ICALP post s.d.</th>
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<th>Lec Gp post mean</th>
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<td>81.98</td>
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<td>50.11</td>
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<td>73.64</td>
<td>7.63</td>
<td>72.47</td>
<td>8.64</td>
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<td>EmbPNS (self-dir'd) pre</td>
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<td>314</td>
<td>13.90</td>
<td>2.92</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
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<td>314</td>
<td>74.10</td>
<td>10.09</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>SDFPN (self-dir'd) pre</td>
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<td>3.02</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
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<td>N/A</td>
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<tr>
<td>SDFPN (self-dir'd) post</td>
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<td>319</td>
<td>75.91</td>
<td>8.83</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Reflex (self-dir'd) pre</td>
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<td>324</td>
<td>13.79</td>
<td>2.95</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Reflex (self-dir'd) post</td>
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<td>325</td>
<td>77.13</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Mean 2-D results 1993 | 31.15 | 74.47 | 4.79 | 8.81 | 37.94 | 73.82 | 5.78 | 8.00 | -0.197 | 0.013 | 0.028 | 0.008 |
From the overall data derived from 2-D experiments in 1992, Table 55-1 delivered mean effect sizes of -0.092 at pretest and 0.021 at posttest, with pre and posttest correlation ratios of 0.013 and 0.051 respectively.

When compared with replicated results in 1993, the summary of data in Table 55-2 shows a mean effect size of -0.197 at pretest and 0.013 at posttest, with pre and posttest correlation ratios of 0.028 and 0.008 respectively. None of these results exceed the base-line values established by the researchers mentioned above, all of which support a view that ICALP materials may be used effectively to deliver 2-D anatomical information at the tertiary level.

On average, none of the mean data presented contravenes the criteria of import to show any meaningful group differences above an effect size of 0.30 and a correlation ratio of 0.10. However, this claim cannot be upheld by specific inspection of 2-D results from the 1992 population in Table 55-1.

Examination of particular 2-D results of the 1992 population in Table 55-1 reveal posttest effect sizes above 0.30 in six areas of study: namely, Cardiac, -0.708; Respiratory, -0.733; CTRS, 0.739; CNS unexpected 60 day re-test, 0.346; CeBar, 0.463; and SFDPN, -0.523. However, in only three of these cases is there a significant increase of posttest correlation ratios above the prescribed value of 0.10. These are; Cardiac, 0.117; Respiratory, 0.117; and CTRS, 0.128.

Observation of box plot formations in 2-D studies of Cardiac, Respiratory and CTRS results in Figures 122-123, 124-125, and 128-129 (pp 276-288) respectively, reveal no disharmony, with a pre-eminence of
the Lecture group during cardiac studies in Figure 122, countered by a pre-eminence of ICALP groups during respiratory and CTRS studies in Figures 124 and 128 respectively. This information may be confirmed by the mean values presented in Tables 16, 20, and 24 (pp 273 to 285). In the remaining areas, the mean values favour the ICALP group over the Lecture group. Namely: a posttest ICALP mean score of 74.03% versus a 75.56% mean from the Lecture group in upper extremity studies (Table 12); a posttest ICALP mean score of 65.55% versus a 63.75% mean from the Lecture group in lower extremity studies (Table 28); a posttest ICALP mean score of 75.42% versus a 73.00% mean from the Lecture group in CNS 2-D studies (Table 32); a posttest ICALP mean score of 70.04% versus a 67.88% mean from the Lecture group achieved in the 120 day re-test following CNS studies (Table 34); a posttest ICALP mean score of 70.23% versus a 71.59% mean from the Lecture group in EmbPNS studies (Table 44); and a posttest ICALP mean score of 68.88% versus a 69.93% mean from the Lecture group in reflex behavioural studies (Table 52.). As may be seen from these results, there are no significant differences between any of the six pairs of sub-groups, with an absolutely even distribution of favourable results for each research category throughout the 1992 2-D anatomy experiments.

Overall, none of the variations discussed above for 2-D studies by the 1992 population, can be identified in the review of 2-D studies exhibited by the 1993 population in Table 55-2. With the exception of a fractional elevation of effect size (0.320) after the unexpected 120 day retest in 1993, no posttest correlation ratio exceeds the established base-line factor of 0.10. Furthermore, the ICALP subgroups achieved a mean posttest score of 74.47% compared with a mean of 73.82% from the Lecture groups.
From these results, apart from observation of any preferred learning style, other group differences may be attributed to the introduction of SOCCER in 1993.

5.3 Primary research conclusion

As verified by Section 5.10.1 at the end of this Chapter, a normal standard of academic excellence was sustained by UG2 students of anatomy throughout the research period of 1992 and 1993. These data are presented in Figures 181 and 182, with Tables 77 and 78 (pp 408 & 409).

The overall ICALP and Lecture group pre and posttest data from the 1992 and 1993 populations in Sections 5.1 and 5.2, were collated to address the primary research question, namely:

*Can ICALP materials be used effectively to replace traditional methods when teaching anatomy to physiotherapy students?*

To reach a primary research conclusion, all of the 2-D information shown in Tables 11 to 54, are reviewed in Tables 55-1 and 55-2. From these data, collective mean variables were collated under the following headings: pre and posttest 2-D and 3-D mean values; pre and posttest effect sizes; and pre and posttest correlation ratios achieved by ICALP and Lecture subgroup populations throughout 1992 and 1993.

As stated in the closing remarks of Sub-sections 5.1.1 to 5.1.10, when averaged, the 2-D achievements of the 1992 and 1993 populations show a close conformity of results at pre and posttest. Overall, the mean values from the ten definitive areas of 2-D research were used to construct
Tables 55-1 and 55-2 to evaluate the 2-D achievements of the ICALP and Lecture groups of the two populations. These data are summarised as follows:

The mean 2-D results at pretest in 1992 and 1993 are:
an ICALP group mean of 31.55%; a Lecture group mean of 35.22%;
an effect size of -0.144; and a correlation ratio of 0.020.

The mean 2-D results at posttest in 1992 and 1993 are:
an ICALP group mean of 73.91%; a Lecture group mean of 73.47%;
an effect size of 0.017; and a correlation ratio of 0.030.

From the summated 2-D data of the 1992-3 populations, it is evident that neither the ICALP nor the Lecture groups were placed at any disadvantage by these research procedures, affirmed by the data given in Figures 181 and 182 and Tables 77 and 78. Notwithstanding data already given by ANOVA, ANCOVA and box plot, overall it would appear that the ICALP groups achieved a marginal advantage over the Lecture groups.

5.3.1 Affirmation of the primary research question
From the accumulated evidence presented and analyses made in Sections 5.1.1 to 5.1.10, this study found that:

ICALP materials can be used effectively to replace traditional methods when teaching anatomy to physiotherapy students.
5.3.2 Affirmation of the first part of the secondary research question

The overall ICALP and Lecture group pre and posttest data from the 1992 and 1993 populations in this section, were collated collectively and separately to address the first part of the secondary research question, namely:

*Can ICALP materials be used effectively to initiate the acquisition of 2-D cognitive anatomical information?*

From analysis of the accumulated evidence presented in Sub-sections 5.1.1 to 5.1.10 above, it is now also possible to affirm that:

*ICALP materials can be used effectively to transfer 2-D cognitive anatomical information.*

5.4 Observation of 3-D experiments in three discrete areas of study

To address the second part of the secondary research question in Section 1.3 (p 3), data were obtained from three groups of courseware listed in Tables 6, 7, and 8 (pp 250-251) to elucidate the influence of 2-D cognitive studies upon the development of a 3-D psycho-motor skill (Section 4.6, p 245). To achieve these aims, pre and posttest results were categorised for comparison with those from 3-D laboratory experiments in three discrete areas of study. The three discrete areas are focused upon, Cardio-Thoracic, Lower Extremity, and Central Nervous Systems in Figures 151 to 162 and Table 72.

To validate the 1992 experiments, the identical 2-D and 3-D procedures were replicated in 1993 in Sections 4.10, 4.11 (pp 247 & 248), and 5.1.4
to 5.1.6 (pp 282-295) together with ANOVA, ANCOVA, and box plot results presented in a uniform sequence.

5.4.1 CTRS 3-D results
The computerized 3-D simulations described in Sections 3.29 and 3.30 (pp 162 and 167), listed in Table 6 (p 250), in combination with results from CTRS laboratory examinations, using human cadaver specimens with the *viva voce* questions validated by Lee & Allison (1992), were used to determine the CTRS 3-D results for this study. These data are amplified by ANOVA in Tables 56 to 59, by ANCOVA in Tables 56-57 and 58-59, review of 3-D results in Table 72, and comparison of GEFT and box plot findings in Figures 151 to 154.

![Figure 151. Comparison of GEFT with 3-D CTRS scores in 1992.](image_url)

The graphic displays in Figures 151 and 152 compare GEFT scores with 3-D results from the experimental population of 1992, which were replicated in 1993.
Figure 152. Comparison of GEFT with 3-D CTRS scores in 1993.

Although randomly selected for designation to ICALP and Lecture groups, unexpectedly, the GEFT scores of the former fared better than the latter, with mean values of 76.67% and 69.75% respectively in 1992, and 82.57% and 79.17% in 1993.

**Table 56. Cardio-Thoracic Respiratory System 3-D pretest 1992.**

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<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
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<td>71.02</td>
<td>11.16</td>
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<td>Lecture</td>
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Significance

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<tr>
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<tr>
<td>Probability</td>
<td>( F = 0.040 ) ( P = 0.841 )</td>
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</tbody>
</table>
Examination of results in Tables 56 and 57 show a remarkable elevation of pretest scores. From this, it is clear that both study groups were already experienced by prior exposure to the topic in 1992. Nevertheless, when compared, the standard deviations of both groups are unusually high at 11.16 from the ICALP group, and 10.28 from the Lecture group in Table 56. Of significance, is the low effect size of 0.048 and a correlation ratio of 0.000.

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
</tr>
<tr>
<td>Effect size (ESI)</td>
</tr>
<tr>
<td>Correlation ratio</td>
</tr>
<tr>
<td>Probability</td>
</tr>
</tbody>
</table>

In contrast with Table 56, at posttest in Table 57 there is a uniform reduction of s.d. values, with a mild elevation of effect size to 0.353 and correlation ratio to 0.031.

<table>
<thead>
<tr>
<th>Table 56-57. ANCOVA of CTRS 3-D pre and posttests 1992.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control-variable</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

339
When viewed by ANCOVA in Table 56-57, there is a close conformity of adjusted scores, with a fractional advantage to the ICALP group.

**Table 58. Cardio-Thoracic Respiratory System 3-D pretest 1993.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>22.70</td>
<td>4.54</td>
<td>1</td>
<td>15.610</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>21.78</td>
<td>3.20</td>
<td>71</td>
<td>1101.952</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>0.287</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation ratio</td>
<td>0.133</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
<td>$F = 1.006$, $P = 0.319$</td>
</tr>
</tbody>
</table>

**Table 59. Cardio-Thoracic Respiratory System 3-D posttest 1993.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>80.63</td>
<td>17.35</td>
<td>1</td>
<td>403.828</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>75.93</td>
<td>18.87</td>
<td>71</td>
<td>23306.856</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>0.249</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation ratio</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
<td>$F = 1.230$, $P = 0.271$</td>
</tr>
</tbody>
</table>

By comparison of the 1992 results with those of 1993 in Tables 58 and 59 and by ANCOVA in Table 58-59, considerable differences may be identified. At pretest, the mean values obtained by the two groups are not only evenly distributed, but also indicate insignificant previous knowledge in the topic. Notwithstanding the remarkably low standard
deviations presented by both groups, the effect size of 0.287 at pretest in Table 58 is almost unchanged at 0.249 at posttest in Table 59.

When assessed by ANCOVA in Table 58-59, the adjusted scores also favour the ICALP group in 3-D examinations of the CTRS in 1993.

<table>
<thead>
<tr>
<th>Table 58-59. ANCOVA of CTRS 3-D pre and posttests 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control-variable</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
</tbody>
</table>

For more explicit comparison, box plots were constructed from the 1992 and 1993 CTRS 3-D data, as shown in Figures 153 and 154.

Figure 153. CTRS 3-D pre-posttests 1992.
The pretest box plot configurations in Figure 153 confirm the high level of knowledge at pretest in the subject by both experimental groups previously referred to in Figure 151 and Tables 56 and 57.

However, the Lecture group at pretest in Figure 153 illustrates a wide box, with equidistant whiskers. This is not the case with the ICALP group, which shows a narrow box, with a more elongated lower whisker. Of more surprise, are the posttest results of both groups. In the case of the Lecture group, there is greater concentration of effort, shown by a compact box at a lower level than at pretest. Nevertheless, the median of the Lecture group at pretest, is seen to rise from 71.40% to 72.80% at posttest. Of interest, is the even distribution of box and whiskers retained by the ICALP group from pre to posttest. In this case, although the outline of box and upper whisker is virtually unchanged, there is a definite elevation overall, with a median upward shift from 74.85% at pretest to 75.47% at posttest.

An immediate observation of pretest values by box plot in Figure 154, affirms that neither group was conversant with the CTRS topic beforehand. In this case, a change of syllabus and influence by academic staff in parallel subjects had not yet affected the 1993 population. Nevertheless, the two posttest box plot displays in Figure 154 confirm the impact of CTRS anatomical experiments in 1993.

When compared, there are certain similarities exhibited by the posttest configurations of the two groups in the CTRS population of 1993. Namely, the location of the median strip and content of the box below it are evenly matched, as are the length and distribution of the two lower whiskers. However, when viewed above the median, it is quite clear that
25% of the Lecture group acquired a score of 83.00% for their CTRS efforts. Furthermore, the upper quartile of the Lecture group is evenly distributed up to 100%. However, these results are eclipsed by the ICALP at posttest, showing the box component above the median to be evenly spread between 83.00% and 100%, together with the absorption of the upper quartile into the box, with a score of 100%.

![Box plot graph showing CTRS 3-D pre-posttests 1993.](image)

From these results, there is clear evidence to show the benefit to be gained from ICALP materials in 3-D CTRS anatomical studies.

### 5.4.2 Lower extremity 3-D results
To address the intrinsic requirements of the second part of the secondary research question, the results of Lower extremity studies in anatomy by UG1 in 1992 were repeated by the same population at UG2 in 1993. To meet these requirements, GEFT scores were recorded for comparison with 3-D results of the two populations in 1992 and 1993. With minor
exceptions, the UG1 population of 1992 were advanced to become the UG2 population of 1993.

Appropriate ICALP and test items listed in Table 7 (p 251), were used as source materials for the lower limb experiments. These items included the 3-D simulations described in Sections 3.29 and 3.30 (pp 162 & 167), to obtain data from computer tests integrated with laboratory examinations, human cadavers, and *viva voce* investigations in 1992 and 1993 (Figures 155 and 156). The 2-D results in Tables 55-1 and 55-2 (pp 330 & 331) may be compared with 3-D results in Table 72 (p 362).

![Chart](image)

**Figure 155.** Lower extremity GEFT scores and 3-D pre and posttest achievements of UG1 in 1992.

In review, Figure 155 presents GEFT scores alongside 3-D achievements of the UG1 population in 1992. In addition, the 3-D information of the 1992 population is given by ANOVA in Tables 60 to 63, and by
ANCOVA in Table 62-63. In the same way, Figure 155 presents the GEFT scores and 3-D results achieved by the UG2 population in 1993.

As may be observed from Figure 155 and Table 60, the ICALP and Lecture groups of the UG1 population in 1992 achieved mean GEFT scores of 79.86% and 82.16% respectively.

![Graph showing GEFT and 3-D scores for Lectures and ICALP groups.]

**Figure 156. Lower extremity GEFT scores and 3-D pre and posttest achievements of UG2 in 1993.**

Comparison of GEFT scores in Figures 155 and 156 with Tables 60 and 61, show no significant variation of achievement by the ICALP and Lecture group members from UG1 in 1992 to UG2 in 1993.

Apart from elevated standard deviations by both ICALP groups, and an increased effect size in 1993, there are no other observable differences in GEFT scores between the UG1 and UG2 populations.
The information in Figures 155 and 156 with Tables 60 and 61, confirm the findings of Lee and Allison (1992), who assert that consistently high levels of GEFT achievement are to be expected from an average undergraduate physiotherapy population. Of greater significance, such
results may not be used with confidence at pretest to predict the outcome of future anatomical results.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
<td><strong>n</strong></td>
</tr>
<tr>
<td>ICALP</td>
<td>36</td>
</tr>
<tr>
<td>Lecture</td>
<td>37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect size (ESI)</td>
<td></td>
<td>0.742</td>
</tr>
<tr>
<td>Correlation ratio</td>
<td></td>
<td>0.124</td>
</tr>
<tr>
<td>Probability</td>
<td></td>
<td><strong>F = 10.045</strong> P = 0.002</td>
</tr>
</tbody>
</table>

Inspection of 3-D pretest results in Table 62 show a 7.48 point advantage to the ICALP group, with an effect size of 0.742 and correlation ratio of 0.124.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
<td><strong>n</strong></td>
</tr>
<tr>
<td>ICALP</td>
<td>36</td>
</tr>
<tr>
<td>Lecture</td>
<td>37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect size (ESI)</td>
<td></td>
<td>0.325</td>
</tr>
<tr>
<td>Correlation ratio</td>
<td></td>
<td>0.029</td>
</tr>
<tr>
<td>Probability</td>
<td></td>
<td><strong>F = 2.181</strong> P = 0.144</td>
</tr>
</tbody>
</table>

Table 63. Lower extremity 3-D posttest scores of UG1 1992.
However, comparison of pretest results with Table 63 at posttest, show a reduced advantage to the ICALP group of 2.01 points, with a marked reduction of effect size to 0.325 and correlation ratio down to 0.029.

By regression analysis, the 1992 results are presented in Table 62-63. The pretest mean values of the ICALP and Lecture groups being, 50.62% and 43.14% respectively. At posttest, Table 62-63 shows a fractional divergence of unadjusted-adjusted scores by the two research categories, with an advantage to the ICALP group overall.

| Table 62-63. ANCOVA of lower extremity 3-D pre and posttests UG1 1992. |
|------------------------|------------------------|
| **Control-variable**   | **Criterion-variable** |
|                       | Pretest                | Posttest               |
| Group                 | n | mean value | adjusted | unadjusted |
| ICALP                 | 36 | 50.62      | 66.53     | 66.24       |
| Lecture               | 37 | 43.14      | 64.38     | 64.23       |

| Table 64. Lower extremity 3-D pretest scores of UG2 1993. |
|------------------------|------------------------|
| **Means table**        | **Analysis of variance** |
| Group                  | n | \( \bar{X} \) | s.d. | df | Sum of Squares |
| ICALP                  | 35 | 45.51      | 9.48 | 1  | 6.993         |
| Lecture                | 38 | 44.89      | 6.67 | 71 | 4715.315     |
| **Significance**       | Effect size (ESI) | 0.092 |
|                        | Correlation ratio | 0.001 |
|                        | Probability | \( F = 0.105 \) \( P = 0.746 \) |
At the UG2 level in 1993, the close proximity of both study groups at pretest is maintained at posttest, as seen in Figure 156, supported by data in Tables 64 and 65.

With the exception of a marginal increase in effect size from pretest to posttest, there are no detectable variations from either research group during 3-D studies of the lower extremity in 1993.

**Table 65. Lower extremity 3-D posttest scores of UG2 1993.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>35</td>
<td>82.25</td>
<td>9.07</td>
<td>1</td>
<td>42.110</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
<td>80.73</td>
<td>8.72</td>
<td>71</td>
<td>5688.164</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
<th>F = 0.530</th>
<th>P = 0.469</th>
</tr>
</thead>
</table>

The uniform data of the UG2 population in Tables 64 and 65, are compared by regression analysis in Table 64-65. From this evidence, the pretest advantage of the ICALP group was sustained during 3-D studies of the lower extremity in 1993.

**Table 64-65. ANCOVA of lower extremity 3-D pre and posttests of UG2 1993.**

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Pretest</td>
</tr>
<tr>
<td></td>
<td>n</td>
</tr>
<tr>
<td>ICALP</td>
<td>35</td>
</tr>
<tr>
<td>Lecture</td>
<td>38</td>
</tr>
</tbody>
</table>

349
For further clarification, the findings from lower extremity experiments were elucidated by box plot in Figures 157 and 158.
In figure 157, apart from a minor variation of lower whisker length, there is a relatively uniform display at pre and posttest by both UG1 groups in 1992. Furthermore, these results clearly favour the ICALP group.

Comparison of findings in Figure 158, also favour the ICALP group, with the exception of minor changes to the length of its whisker, showing a distinct advantage over the Lecture group at posttest.

From these results, there is clear evidence in favour of ICALP materials to assist undergraduate anatomists acquire 3-D information about the lower extremities.

5.4.3 CNS 3-D results

The seven ICALP and pre-posttest items in Table 8 (p 251) were applied as learning and test resources for the central nervous system (CNS) component of this research project in 1992 and 1993.

The conditions of 3-D simulations described in Sections 3.29 and 3.30 (pp 162 & 167), were integrated with human cadaver experiments, laboratory examinations, and the Problem Based Learning strategies described in Sections 3.40, 3.41, and 4.14 (pp 231, 232, & 259).
Figure 159. C.N.S. GEFT and 3-D test scores achieved by UG2 in 1992.

Figure 160. C.N.S. GEFT and 3-D test scores achieved by UG2 in 1993.
When compared, important observations may be made about 1992 and 1993 results in Figures 159 and 160.

Firstly, the 1992 population became highly motivated by the CNS study, supported by recorded efforts in Table 73-4 and review of 2-D and 3-D results in Tables 55-1, 55-2, and 72. Secondly, with the exception of differing levels of success, both groups maintained the same configuration of pre and posttest results in Figures 159 and 160.

These data may be affirmed by comparison of differences in Figures 159 and 160, with ANOVAs in Tables 66 to 71, ANCOVAs in Tables 68-69 and 70-71, and by box plot in Figures 161 and 162.

<table>
<thead>
<tr>
<th>Table 66. CNS GEFT scores 1992.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>ICALP</td>
</tr>
<tr>
<td>Lecture</td>
</tr>
<tr>
<td>Significance</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Tables 66 and 67 contain GEFT scores of the 1992 and 1993 populations respectively. It is noteworthy that a significant improvement occurred in the level of success by both subgroups between 1992 to 1993. However, with the exception of abnormally wide standard deviations at pretest by
both groups in Table 66, the relative differences between them remained the same in Table 67.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>82.57</td>
<td>7.87</td>
<td>1</td>
<td>211.042</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>79.17</td>
<td>11.92</td>
<td>71</td>
<td>7206.081</td>
</tr>
</tbody>
</table>

Investigations of the CNS 3-D pretest scores of the 1992 in Table 68 indicate no significant differences, apart from a mild disparity of s.d. values at posttest by the ICALP group in Table 67.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>39</td>
<td>42.08</td>
<td>7.48</td>
<td>1</td>
<td>60.608</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>40.32</td>
<td>7.97</td>
<td>77</td>
<td>4603.544</td>
</tr>
</tbody>
</table>

| Significance | Effect size (ESI) | 0.221 |
|              | Correlation ratio  | 0.013 |
|              | Probability        | F = 1.014, P = 0.317 |
Comparison of Tables 68 and 69 provide constant differences of mean values between the ICALP and Lecture groups, supported by a concordance of effect size and correlation ratio.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>39</td>
<td>84.72</td>
<td>10.60</td>
<td>1</td>
<td>80.411</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>82.70</td>
<td>7.74</td>
<td>77</td>
<td>6608.297</td>
</tr>
</tbody>
</table>

**Effect size (ESI)**: 0.261

**Correlation ratio**: 0.012

**Probability**: $F = 0.937$, $P = 0.336$

The data in Tables 68 and 69 are verified by ANCOVA in Table 68-69, only to be confused by adjusted values which favour the Lecture group, despite pretest and unadjusted posttest values which favour the ICALP group.

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>ICALP</td>
<td>39</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
</tr>
</tbody>
</table>

In 1993, 3-D scores of CNS materials in Table 70 marginally favour the ICALP group, with no other controversial evidence at pretest.
Table 70. CNS 3-D pretest scores 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>40.24</td>
<td>7.22</td>
<td>1</td>
<td>2.664</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>39.86</td>
<td>7.88</td>
<td>71</td>
<td>4053.116</td>
</tr>
</tbody>
</table>

Significance

<table>
<thead>
<tr>
<th>Effect size (ESI)</th>
<th>0.148</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>0.001</td>
</tr>
<tr>
<td>Probability</td>
<td>$F = 0.047$ $P = 0.829$</td>
</tr>
</tbody>
</table>

However, Table 71 shows a minor advantage to the Lecture group by a mean value of 67.32%, compared with a mean of 65.77% obtained by the ICALP group at posttest.

Table 71. CNS 3-D posttest scores 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{X}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>65.77</td>
<td>6.71</td>
<td>1</td>
<td>44.103</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>67.32</td>
<td>7.40</td>
<td>71</td>
<td>3584.557</td>
</tr>
</tbody>
</table>

Significance

<table>
<thead>
<tr>
<th>Effect size (ESI)</th>
<th>-0.209</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation ratio</td>
<td>0.012</td>
</tr>
<tr>
<td>Probability</td>
<td>$F = 0.884$ $P = 0.350$</td>
</tr>
</tbody>
</table>

These data are affirmed by ANCOVA in Table 70-71, confounded by adjusted values which favour the ICALP group, despite pre-eminence by the Lecture group in Table 71.
Table 70-71. ANCOVA of CNS 3-D pre and posttests 1993.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>mean value</th>
<th>Posttest adjusted</th>
<th>Posttest unadjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICALP</td>
<td>37</td>
<td>40.24</td>
<td>67.17</td>
<td>65.77</td>
</tr>
<tr>
<td>Lecture</td>
<td>36</td>
<td>39.86</td>
<td>65.95</td>
<td>67.32</td>
</tr>
</tbody>
</table>

To elucidate the matter further, box plot comparisons were constructed for both populations of 3-D CNS studies in 1992 and 1993. The outcome is shown by Figures 161 and 162.

The mild disparity of both groups at pretest in Table 68, is amplified by box plot in Figure 161.

Figure 161. CNS 3-D pre-posttests 1992.
With the exception of extraneous outliers at posttest, the box plot results in Figure 161 clearly favour the ICALP group for 3-D CNS studies in 1992.

![Box plot diagram showing comparison between lectures and ICALP groups pretest and posttest in 1993.](image)

**Figure 162. CNS 3-D pre-posttests 1993.**

In 1993, although at a lower level, the uniformity of box and whiskers exhibited by the Lecture group is preferable to that of the ICALP group at pretest. At posttest, there is close conformity of effort from both groups, confounded by two extraneous outliers below the ICALP group.

Nevertheless, Figure 162 shows a general advantage to the ICALP members throughout 3-D CNS research in 1993'.

Notwithstanding the importance of statistically insignificant effect sizes and correlation ratios, there is considerable evidence which supports the use of ICALP materials to acquire 3-D anatomical information about the central nervous system.
5.5 Summary of 3-D ICALP experiments

When summarised for review, the resultant 3-D data presented in Sections 5.4.1 to 5.4.3 were applied to resolve the second part of the secondary research question expressed in Section 1.3 (p 3). From these data, comparisons were made to identify any relative differences between the research groups of the 1992 and 1993 populations. This investigation scrutinised pre and posttest information from 3-D experiments, which include: mean values; effect size estimators; correlation ratios; regression analyses; and box plot displays.

The 3-D investigations were confined to three discrete areas of research, namely, lower extremity; cardio-thoracic-respiratory; and central nervous system (Sections 4.13.2 to 4.13.6; pp 253-256). From these three areas, sufficient 3-D information was gathered from laboratory examinations, using prepared human cadaver specimens, and live models integrated with the viva voce questions validated by Lee and Allison in 1992.

The review of significant authors who used meta-analysis to standardise effect size estimators, and correlation ratios, in the summary of 2-D experiments in Section 5.2 (p 328) was applied to address the secondary research conclusion. Briefly, these are: Kulik, Bangert and Williams (1983), who showed an average effect size of 0.49 in five studies at the secondary school level; Kulik and Kulik (1985) who, in 10 studies at the tertiary level, determined an average effect size of 0.36; Kulik, Kulik and Scwalb (1985), who identified an average effect size of 1.13 in computer simulations from two studies in adult education; Fraser, Walberg, Welch and Hattie (1987), who quantified an average effect size of 0.4 in a synthesis of 134 meta-analyses from 7,827 studies in education; Kulik
and Kulik (1991), who assert an average effect size of 0.3 for CAL; McKenna (1993), who found a mean effect size of 0.38 by meta-analysis of 26 educational computer simulations; Teh (1993), who identified an effect size of 0.3 during the evaluation of computer-assisted learning in geography; and Abik (1994), who furnished effect size estimator averages of 0.69, 0.85, and 0.83 in three areas of CAL to improve the performance of 2,187 chemistry students in 32 high school classes.

With these authenticated criteria of import, the results from three discrete areas of 3-D were extracted from the 1992 and 1993 research populations. These data are reviewed in Table 72. Observation of these data identify group differences among results, such as variations of box plot patterns, differences in posttest values, and any increase of effect sizes above 0.30 or correlation ratio in excess of 0.10.

Table 72 summarises mean 3-D results from experiments in 1992 and 1993. From these data it may be seen that the 3-D experiments in 1992 demonstrate a pretest effect size of 0.337 and 0.313 at posttest, with pre and posttest correlation ratios of 0.046 and 0.024 respectively. In the same way, Table 72 provides a summary of data obtained by the 1993 population in replicated experiments, showing pre and posttest effect sizes of 0.176 and 0.071, with pre and posttest correlation ratios of 0.045 and 0.012.

On average, none of these data contravene the criteria of import reviewed above, with no significant group differences above an effect size of 0.30 and a correlation ratio of 0.10. This claim cannot be fully substantiated by inspection of 3-D results from the 1992 population in
Table 72, which show a mild elevation in effect size of 0.353 and 0.325 at posttest for CTRS and Lower extremity results (Tables 57 & 63).
<table>
<thead>
<tr>
<th>Table 72</th>
<th>Review of 3-D results obtained in 1992 and 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3-D results 1992</strong></td>
<td>Table</td>
</tr>
<tr>
<td></td>
<td>no</td>
</tr>
<tr>
<td>CTRS pretest</td>
<td>57</td>
</tr>
<tr>
<td>CTRS posttest</td>
<td>58</td>
</tr>
<tr>
<td>Lower ext’y pre (UG1)</td>
<td>63</td>
</tr>
<tr>
<td>Lower ext’y post (UG1)</td>
<td>64</td>
</tr>
<tr>
<td>CNS pretest</td>
<td>67</td>
</tr>
<tr>
<td>CNS posttest</td>
<td>68</td>
</tr>
<tr>
<td><strong>Mean 3-D results 1992</strong></td>
<td>54.57</td>
</tr>
<tr>
<td><strong>3-D results 1993</strong></td>
<td>Table</td>
</tr>
<tr>
<td></td>
<td>no</td>
</tr>
<tr>
<td>CTRS pretest</td>
<td>59</td>
</tr>
<tr>
<td>CTRS posttest</td>
<td>60</td>
</tr>
<tr>
<td>Lower ext’y pre (UG2)</td>
<td>65</td>
</tr>
<tr>
<td>Lower ext’y post (UG2)</td>
<td>66</td>
</tr>
<tr>
<td>CNS pretest</td>
<td>69</td>
</tr>
<tr>
<td>CNS posttest</td>
<td>70</td>
</tr>
<tr>
<td><strong>Mean 3-D results 1993</strong></td>
<td>36.15</td>
</tr>
</tbody>
</table>
Overall, Table 72 shows a mean of 75.39% which favours the ICALP groups compared with a composite mean of 73.22% achieved by the Lecture groups in 1992. Similar observations may be made about the 1993 population in Table 72. Although the composite ICALP mean of 76.22% pre-empts the Lecture group mean of 74.66%, in both cases there is a uniform widening of posttest s.d. values beyond those of 1992. Nevertheless, these differences are ameliorated by a composite posttest effect size of 0.071 and correlation ratio of 0.012. From these data, no statistically significant variations may be observed from the three areas of 3-D experimentation applied in 1992 and 1993.

5.6 Secondary research conclusions

To answer the second part of the secondary research question, namely:

*Can ICALP materials be used instead of lectures to transfer 2-D information into an effective 3-D anatomical skill?*

In the manner used to reach the primary research conclusion in Section 5.3 (p 334), it was considered necessary to re-establish the 3-D information from the ICALP and Lecture research groups of 1992 and 1993. Namely:

At 3-D pretest in 1992, these are:
- an ICALP group mean of 54.57%; a Lecture group mean of 51.33%;
- an effect size of 0.337; and a correlation ratio of 0.046.

At 3-D posttest 1992, these are:
- an ICALP group mean of 75.39%; a Lecture group mean of 73.22%;
- an effect size of 0.313; and a correlation ratio of 0.024.
At 3-D pretest in 1993, these are:
an ICALP group mean of 36.15%; a Lecture group mean of 35.51%;
an effect size of 0.176; and a correlation ratio of 0.045.

At 3-D posttest 1993, these are:
an ICALP group mean of 76.22%; a Lecture group mean of 74.66%;
an effect size of 0.071; and a correlation ratio of 0.012.

When viewed overall, the average 3-D achievements of the 1992 and 1993 populations show a close conformity of results at pre and posttest. Although a distinct qualitative advantage is apparent to the ICALP population overall, there is insufficient statistical evidence in support of a positive conclusion about the main effect of computerized intervention.

These data may be affirmed by Table 72, with a range of composite mean values which show an effect size of 0.256 at pretest and 0.192 at posttest, and a correlation ratio of 0.045 at pretest and 0.018 at posttest.

5.6.1 Affirmation of the second part of the secondary research question

From the accumulated data of 3-D investigations throughout 1992 and 1993, there are no significant differences between the Lecture and ICALP groups, with sufficient quantitative evidence to favour an ICALP approach to 3-D studies. Therefore, these results are used to affirm:

That ICALP materials can be used instead of lectures to transfer 2-D information into an effective 3-D anatomical skill.
5.7 Observation of test, learning, and revisionary ICALP activities

The database acquired to resolve the primary and secondary research conclusions reached in Sections 5.3 and 5.6 was also used to address the three subsidiary research questions regarding the cost-effectiveness of ICALP materials delineated in Section 1.4 of this thesis (p 4). To evaluate the cost-effectiveness of ICALP materials to academic staff members, individual students, and tertiary administrators, a continuous stream of data was accumulated from the ten ICALP experiments promulgated in 1992, which were then validated by replication in 1993. These data are given in Tables 73-1 to 73-6 which coincide with the ten areas of research described below.

5.7.1 Upper extremity ICALP activities

Detailed observation of the Upper Extremity data recorded by UG1 and UG2 students in 1992 and 1993 are recorded in Table 73-1. This serves to exemplify the rate of primary learning by ICALP groups and the revision activities of the entire population in the CMLE thereafter. Table 73-1 shows the average time taken at pretest by UG1 students in 1992 as 55.23 minutes, followed by 52.00 minutes, and 54.00 minutes by the UG2 populations of 1992 and 1993. These data may be compared with an average posttest time of 36.27 minutes by UG1 in 1992, with 38.45, and 47.00 minutes respectively, by the UG2 populations of 1992 and 1993. These data may be quantified further, where the UG2 population of 1992 registered average pre and posttest clicks per minute of 5.00 and 4.45 respectively. In the same way, the pre and posttest results of the same population, show an improved correct click average of 1.75 to 3.32 per minute, corresponding to average scores of 35.19% and 74.80% respectively.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Number of computer sessions</th>
<th>Total time (hours)</th>
<th>Ave session (minutes)</th>
<th>Ave clicks p.min</th>
<th>Ave correct clicks p.min</th>
<th>Ave error clicks p.min</th>
<th>Ave % score per session</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Extremity 1992 (UG1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>74</td>
<td>68.11</td>
<td>55.23</td>
<td>7.05</td>
<td>2.50</td>
<td>4.55</td>
<td>35.60</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>737</td>
<td>658.50</td>
<td>53.21</td>
<td>3.10</td>
<td>2.54</td>
<td>0.56</td>
<td>82.24</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
<td>44.73</td>
<td>36.27</td>
<td>3.75</td>
<td>2.81</td>
<td>0.94</td>
<td>75.00</td>
</tr>
<tr>
<td>Revision</td>
<td>446</td>
<td>165.46</td>
<td>22.26</td>
<td>2.35</td>
<td>2.23</td>
<td>0.12</td>
<td>95.24</td>
</tr>
<tr>
<td><strong>Upper Extremity 1992 (UG2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
<td>68.46</td>
<td>52.00</td>
<td>5.00</td>
<td>1.75</td>
<td>3.25</td>
<td>35.19</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>517</td>
<td>441.69</td>
<td>51.26</td>
<td>2.06</td>
<td>1.90</td>
<td>0.16</td>
<td>92.30</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
<td>50.62</td>
<td>38.45</td>
<td>4.45</td>
<td>3.32</td>
<td>1.13</td>
<td>74.80</td>
</tr>
<tr>
<td>Revision</td>
<td>363</td>
<td>111.32</td>
<td>18.40</td>
<td>1.92</td>
<td>1.86</td>
<td>0.06</td>
<td>97.37</td>
</tr>
<tr>
<td><strong>Upper Extremity 1993 (UG2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pretest</td>
<td>73</td>
<td>65.70</td>
<td>54.00</td>
<td>3.90</td>
<td>1.36</td>
<td>2.54</td>
<td>34.94</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>458</td>
<td>345.79</td>
<td>45.30</td>
<td>1.78</td>
<td>1.60</td>
<td>0.18</td>
<td>89.98</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
<td>57.18</td>
<td>47.00</td>
<td>2.70</td>
<td>1.94</td>
<td>0.76</td>
<td>72.19</td>
</tr>
<tr>
<td>Revision</td>
<td>354</td>
<td>174.75</td>
<td>29.62</td>
<td>1.24</td>
<td>1.09</td>
<td>0.15</td>
<td>88.38</td>
</tr>
</tbody>
</table>
It is noteworthy that the learning rate of the ICALP group at 92.30%, represents an average of 2.06 clicks per minute with an average click error rate of 0.16. A sustained level of attention by the 1992 population during revision is shown by 363 visits, at an average of 18.40 minutes, scoring a mean of 97.37% at an average of 1.92 clicks per minute at an average error rate of 0.06.

Although satisfactory, the quality of excellence shown in 1992 appears not to have been sustained in 1993. The pre and posttest mean scores of 34.94% and 72.19% in 1993 may be compared to 35.19% and 74.80% achieved in 1992. The quality of learning by the ICALP group in 1993 is slightly lower at 89.98% compared to the 92.30% achieved by ICALP in 1992. This disparity is more evident when comparing revisionary efforts. Although the number of revision sessions attended in 1992 is comparable with 1993 at a rate of 1.09 clicks per minute in 1993, against a rate of 1.92 clicks per minute in 1992. From this, there is an observable difference of attention to revision, recorded by 97.37% in 1992, in comparison with 88.38% recorded in 1993.

5.7.2 Cardiac ICALP activities

Observation of Cardiac pre and posttest results, alongside learning and revision activities during 1992 and 1993, can be placed into perspective by view of Table 73-2. Although the pretest scores of the 1992 population were somewhat lower than that of 1993, at posttest the outcome favoured the former. Of further interest, is that the 1993 population was caused to revisit the cardiac software to a greater extent for revision than its counterpart in 1992. This is evidenced by a differential of N=73 in 1993, compared with N=79 in 1992. In 1993, 246 sessions were registered for revision over a period of 118.9 hours.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Number of computer sessions</th>
<th>Total time (hours)</th>
<th>Ave session (minutes)</th>
<th>Ave clicks p.min</th>
<th>Ave correct clicks p.min</th>
<th>Ave error clicks p.min</th>
<th>Ave % score per session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac 1992</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
<td>46.34</td>
<td>35.20</td>
<td>8.29</td>
<td>2.81</td>
<td>5.48</td>
<td>33.90</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>124</td>
<td>62.00</td>
<td>30.00</td>
<td>4.77</td>
<td>4.14</td>
<td>0.63</td>
<td>87.00</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
<td>38.68</td>
<td>29.38</td>
<td>6.50</td>
<td>5.54</td>
<td>0.96</td>
<td>85.35</td>
</tr>
<tr>
<td>Revision</td>
<td>236</td>
<td>71.98</td>
<td>18.30</td>
<td>2.40</td>
<td>2.11</td>
<td>0.29</td>
<td>88.00</td>
</tr>
<tr>
<td>Cardiac 1993</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
<td>40.75</td>
<td>33.50</td>
<td>7.50</td>
<td>3.27</td>
<td>4.23</td>
<td>43.71</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>109</td>
<td>52.68</td>
<td>29.00</td>
<td>3.39</td>
<td>2.94</td>
<td>0.45</td>
<td>87.00</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
<td>33.33</td>
<td>27.40</td>
<td>5.90</td>
<td>4.78</td>
<td>1.12</td>
<td>81.06</td>
</tr>
<tr>
<td>Revision</td>
<td>246</td>
<td>118.90</td>
<td>29.00</td>
<td>4.77</td>
<td>4.19</td>
<td>0.58</td>
<td>88.00</td>
</tr>
<tr>
<td>Respiratory 1992</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
<td>41.40</td>
<td>31.45</td>
<td>8.10</td>
<td>2.75</td>
<td>5.35</td>
<td>34.06</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>116</td>
<td>56.06</td>
<td>29.00</td>
<td>2.96</td>
<td>2.49</td>
<td>0.47</td>
<td>84.41</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
<td>57.93</td>
<td>44.00</td>
<td>6.57</td>
<td>5.07</td>
<td>1.50</td>
<td>77.19</td>
</tr>
<tr>
<td>Revision</td>
<td>86</td>
<td>39.15</td>
<td>27.32</td>
<td>2.87</td>
<td>2.56</td>
<td>0.31</td>
<td>89.34</td>
</tr>
<tr>
<td>Respiratory 1993</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
<td>40.45</td>
<td>33.25</td>
<td>7.43</td>
<td>3.24</td>
<td>4.19</td>
<td>43.69</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>244</td>
<td>191.13</td>
<td>47.00</td>
<td>4.93</td>
<td>4.88</td>
<td>0.05</td>
<td>99.00</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
<td>34.06</td>
<td>28.00</td>
<td>3.65</td>
<td>2.68</td>
<td>0.97</td>
<td>73.65</td>
</tr>
<tr>
<td>Revision</td>
<td>332</td>
<td>271.13</td>
<td>49.00</td>
<td>1.41</td>
<td>1.25</td>
<td>0.16</td>
<td>89.00</td>
</tr>
</tbody>
</table>
In 1992, 236 sessions were registered for revision over a period of 71.98 hours. These data reflect an average session rate of 29 minutes in the former, and 18.30 minutes in the latter. However, this may be countered by an increased quality of revision in 1992, shown by an average click rate of 2.11 per minute, with an average error rate of only 0.29 clicks per minute. These results may be compared with an average rate of 4.19 correct clicks per minute, and an average error rate of 0.58 clicks per minute in 1993.

5.7.3 Respiratory ICALP activities

When the results shown in Table 73-2 are aligned to view the quality of responses to respiratory software during tests, learning, and revision, there are observable differences between the 1992 and 1993 populations. Of further interest is that although the pretest mean of the 1992 population was 34.06%, it was effectively 9.63 points lower than the 1993 cohort, which acquired a mean score of 43.69%. By comparison, it appears that the 1992 population may have been satisfied with an advancement from a mean of 34.06% at pretest, to 77.19% at posttest. This view may be supported by only 86 visits for revision in 1992 compared with 332 visits in 1993. Scrutiny of these data demonstrate the effectiveness of tracking mechanisms provided by SOCCER to enable comparative assertions to be made about one population with another. An example of this may be seen by comparison of the population size of 1992 with that of 1993 with the relative differences of time, rate, the number of correct and error clicks per minute, and mean scores whilst doing so. These data coincide with a perceived need created in the 1993 population by a change of strategies by academic staff in parallel subjects.
<table>
<thead>
<tr>
<th>Table 73-3</th>
<th>Detailed view of ICALP activities in 1992 and 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic</strong></td>
<td><strong>Number of computer sessions</strong></td>
</tr>
<tr>
<td><strong>CTRS 1992</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>153</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
</tr>
<tr>
<td>Revision</td>
<td>112</td>
</tr>
<tr>
<td><strong>CTRS 1993</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>149</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
</tr>
<tr>
<td>Revision</td>
<td>169</td>
</tr>
<tr>
<td><strong>Lower Extremity 1992 (UG1)</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>74</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>272</td>
</tr>
<tr>
<td>Posttest</td>
<td>74</td>
</tr>
<tr>
<td>Revision</td>
<td>258</td>
</tr>
<tr>
<td><strong>Lower Extremity 1992 (UG2)</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>257</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
</tr>
<tr>
<td>Revision</td>
<td>223</td>
</tr>
</tbody>
</table>
5.7.4 CTRS ICALP activities

From the evidence in Table 73-3, no observable disadvantages beset the ICALP groups during CTRS studies in 1992 and 1993. This is confirmed by the rates of learning and revision whilst doing so. The 1992 ICALP group attended 153 sessions with a total of 114.75 hours, at an average of 45 minutes. Whilst learning, the ICALP group sustained an average rate of 1.53 clicks per minute, at an error rate of 0.34, with a success rate of 78.00%. The revision rate of the 1992 population shows 112 sessions of short bursts at an average rate of 22.15 minutes, presenting a level of attention at 92.00%. The same quality of excellence is shown by the 1993 population, with 149 ICALP sessions with a total of 47.18 hours, at an average of 19 minutes with an attention level of 92.00%. Although a smaller population, the revision rate of the 1993 population registered 169 sessions, in short bursts at an average of 24 minutes, with a rate of 90.00%.

This information supports the view expressed in Sections 5.1.3 (p 277) and 5.7.3 above, regarding 2-D and 3-D results respectively, which can be attributed to a positive effectiveness by academic colleagues in parallel subjects.

5.7.5 Lower extremity ICALP activities

The effort devoted to the lower extremity by the UG1 and UG2 populations in 1992 and 1993 is reviewed in Table 73-3. Of interest is an apparent need to increase the level of personal satisfaction suggested by differences in behaviour by UG1 members in 1992 compared with their efforts as UG2 students in 1993. In 1992, the UG1 cohort devoted a total of 445.21 hours in 678 sessions of testing, learning and revision.
<table>
<thead>
<tr>
<th>Table 73-4</th>
<th>Detailed view of ICALP activities in 1992 and 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of computer sessions</td>
</tr>
<tr>
<td><strong>Lower Extremity 1993 (UG2)</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>295</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
</tr>
<tr>
<td>Revision</td>
<td>633</td>
</tr>
<tr>
<td><strong>CNS 1992</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>252</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
</tr>
<tr>
<td>60 day retest</td>
<td>79</td>
</tr>
<tr>
<td>120 day retest</td>
<td>79</td>
</tr>
<tr>
<td>Revision</td>
<td>576</td>
</tr>
<tr>
<td><strong>CNS 1993</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>261</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
</tr>
<tr>
<td>60 day retest</td>
<td>73</td>
</tr>
<tr>
<td>120 day retest</td>
<td>73</td>
</tr>
<tr>
<td>Revision</td>
<td>776</td>
</tr>
</tbody>
</table>
In 1993, the same cohort in UG2, devoted a total of 558.99 hours in 1,074 sessions of testing, learning and revision in the same subject. Apart from any motivational differences during the academic progress of this population, the main effect can be attributable to the introduction of SOCCER, which became available to enhance the CMLE in 1993.

5.7.6 CNS ICALP activities

To some extent, the apparent differences between the 1992 and 1993 populations in Figures 134 and 135 (pp 296 & 297) can be verified by the activities summarised in Table 73-4. Overall, the 1992 population devoted 835.79 hours to studies of the CNS compared with a total of 670.61 hours applied in the subject by the smaller population of 1993. However, after consideration of the population sizes in 1992 and 1993, any difference is a matter of preferred style. In CNS studies, the 1992 population devoted a total of 1,144 sessions, at an average of 40.58 hrs, with a 95.62% level of accuracy whilst learning at a rate of 6.05 clicks per minute. The same population sustained an attention rate of 97.20%, at 1.84 clicks per minute during revision. By comparison, the 1993 population reached a total of 1,329 sessions, at an average of 35.45 hours, with a 90.00% level of accuracy whilst doing so. Furthermore, the 1993 CNS population show a learning rate at 3.73 clicks per minute, with a 90.00% level of accuracy, and an average of 2.13 clicks per minute, with a 90.57% level of accuracy during revision

The CNS data may also be used to evaluate and compare relative differences in performance during pre, post, and 60 or 120 day re-test procedures.
5.7.7 Cerebellar ICALP activities

Table 73-5 shows an intensity of CeBar effort by the 1992 population with 1,051 attendances, at an average of 55.13 minutes, in a total period of 1,194.95 hrs. In the same subject, the smaller population of 1993, show a total of 1,257 attendances at an average of 43.99 minutes, over a period of 1,087.74 hours. Of more significance, is the low click-rate sustained during learning and revision by both populations. Namely, the 1992 population worked at an average of 1.51 clicks per minute, with an error rate of 0.23 clicks per minute, presenting a mean attention rate of 84.54% during learning and revision. These data are matched by the 1993 population, who worked at 1.53 clicks per minute, with an error rate of 0.15 at a sustained attention rate of 90.66% during learning and revision.

5.7.8 EmbPNS ICALP activities

The respective styles of learning and revision from the EmbPNS software in 1992 and 1993, are shown in Table 73-5. The 1992 population used the EmbPNS items for a total of 507.70 hours in 638 sessions, at an average of 43.33 minutes each. During learning and revision, the same population averaged 1.40 clicks per minute, at an average error rate of 0.11, sustaining an average attention rate of 93.04% whilst doing so. In 1993, the same EmbPNS software was used for 279.01 hours in 517 sessions, each at an average of 28.56 minutes. During learning and revision, the 1993 population registered an average of 1.65 clicks per minute, with an error rate of 0.07, whilst sustaining an average attention rate of 96.69%. From these data, it is evident that the 1993 population developed an accurate and confident approach to autonomous learning with the advent of SOCCER.
<table>
<thead>
<tr>
<th>Table 73 - 5</th>
<th>Detailed view of ICALP activities in 1992 and 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of computer sessions</td>
</tr>
<tr>
<td><strong>CeBar 1992</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>440</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
</tr>
<tr>
<td>Revision</td>
<td>453</td>
</tr>
<tr>
<td><strong>CeBar 1993</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>807</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
</tr>
<tr>
<td>Revision</td>
<td>304</td>
</tr>
<tr>
<td><strong>EmbPNS 1992</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>189</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
</tr>
<tr>
<td>Revision</td>
<td>291</td>
</tr>
<tr>
<td><strong>EmbPNS 1993</strong></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>225</td>
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<tr>
<td>Posttest</td>
<td>73</td>
</tr>
<tr>
<td>Revision</td>
<td>146</td>
</tr>
</tbody>
</table>
5.7.9 SFDNP ICALP activities

The styles of learning and revision from the structure, function, and dysfunction of peripheral nerve (SFDNP) software by the 1992 and 1993 populations is reviewed in Table 73-6. The 1992 population used these resources for a total of 735.35 hours in 803 sessions, at an average of 47.07 minutes each. During learning and revision, the 1992 population registered an average 1.26 clicks per minute at an average error rate of 0.14 clicks per minute, sustaining an attention rate of 88.88% whilst doing so. The 1993 population used the same software in a total of 766.50 hours over 770 sessions, each at an average of 49.94 minutes. Throughout learning and revision, the 1993 population averaged 1.09 clicks per minute at an error rate of 0.17 with an attention rate of 84.85% in the process. From these data, it is evident that both research populations devoted considerable time and effort to master this complex subject. It is important to note that the 1993 population completed this task in less time than its predecessors in a problem-based environment (pp 231 to 239, and Section 4.14, p 259) without any need to attend traditional lectures in the subject whatsoever.

5.7.10 Reflex ICALP activities

The respective styles of learning and revision tracked from Reflex software in 1992 and 1993 are shown in Table 73-6. In 1992, the Reflex resources were used for a total period of 279.52 hours in 475 sessions, at an average time of 29.65 minutes. During learning and revision, in 1992, an average 1.26 clicks per minute were applied with an error rate of 0.23, maintaining an attention rate of 79.21% whilst doing so. By contrast, in 1993, the same software was used for 374.70 hours in 658 sessions, at an average of 31.52 minutes.
<table>
<thead>
<tr>
<th></th>
<th>Number of computer sessions</th>
<th>Total time (hours)</th>
<th>Ave session (minutes)</th>
<th>Ave clicks p.min</th>
<th>Ave correct clicks p.min</th>
<th>Ave error clicks p.min</th>
<th>Ave % score per session</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SFDPN 1992</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
<td>43.45</td>
<td>33.00</td>
<td>2.02</td>
<td>0.62</td>
<td>1.40</td>
<td>30.85</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>237</td>
<td>237.35</td>
<td>60.09</td>
<td>0.90</td>
<td>0.80</td>
<td>0.10</td>
<td>89.34</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
<td>46.08</td>
<td>35.00</td>
<td>2.03</td>
<td>1.50</td>
<td>0.53</td>
<td>74.13</td>
</tr>
<tr>
<td>Revision</td>
<td>408</td>
<td>408.47</td>
<td>60.07</td>
<td>1.63</td>
<td>1.44</td>
<td>0.19</td>
<td>88.42</td>
</tr>
<tr>
<td><strong>SFDPN 1993</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
<td>43.31</td>
<td>35.60</td>
<td>1.96</td>
<td>0.52</td>
<td>1.44</td>
<td>27.02</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>341</td>
<td>341.39</td>
<td>60.07</td>
<td>0.76</td>
<td>0.65</td>
<td>0.11</td>
<td>85.97</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
<td>37.96</td>
<td>31.20</td>
<td>1.87</td>
<td>1.42</td>
<td>0.45</td>
<td>76.00</td>
</tr>
<tr>
<td>Revision</td>
<td>283</td>
<td>343.84</td>
<td>72.90</td>
<td>1.43</td>
<td>1.19</td>
<td>0.24</td>
<td>83.73</td>
</tr>
<tr>
<td><strong>Reflex 1992</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>79</td>
<td>31.60</td>
<td>24.00</td>
<td>4.84</td>
<td>0.89</td>
<td>3.95</td>
<td>18.49</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>83</td>
<td>39.56</td>
<td>28.60</td>
<td>1.73</td>
<td>1.49</td>
<td>0.24</td>
<td>86.41</td>
</tr>
<tr>
<td>Posttest</td>
<td>79</td>
<td>25.06</td>
<td>19.00</td>
<td>1.27</td>
<td>0.88</td>
<td>0.39</td>
<td>69.40</td>
</tr>
<tr>
<td>Revision</td>
<td>234</td>
<td>183.30</td>
<td>47.00</td>
<td>0.79</td>
<td>0.56</td>
<td>0.23</td>
<td>72.01</td>
</tr>
<tr>
<td><strong>Reflex 1993</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>73</td>
<td>35.77</td>
<td>29.40</td>
<td>3.72</td>
<td>0.51</td>
<td>3.21</td>
<td>13.80</td>
</tr>
<tr>
<td>ICALP learning</td>
<td>340</td>
<td>216.63</td>
<td>38.23</td>
<td>0.55</td>
<td>0.45</td>
<td>0.10</td>
<td>82.73</td>
</tr>
<tr>
<td>Posttest</td>
<td>73</td>
<td>33.38</td>
<td>27.44</td>
<td>0.68</td>
<td>0.52</td>
<td>0.16</td>
<td>77.19</td>
</tr>
<tr>
<td>Revision</td>
<td>172</td>
<td>88.92</td>
<td>31.02</td>
<td>0.96</td>
<td>0.89</td>
<td>0.07</td>
<td>93.40</td>
</tr>
</tbody>
</table>
During learning and revision, the 1993 Reflex population averaged 1.51 clicks per minute at an average error rate of 0.08, with an attention rate of 88.06%. When compared with their 1992 counterpart, it is clear that the 1993 population had developed a competent approach to autonomous learning by the advent of SOCCER.

The observed results and content of the 1992-93 research activities listed in Tables 73-1 to 73-6, will be used to support each of the three subsidiary research conclusions in the next section.

5.8 Subsidiary research conclusions

The collective data from Sections 5.1, 5.3, and 5.7, may now be applied to address the three subsidiary research questions, namely:

*When objectively compared with traditional methods, what is the relative cost-effectiveness of ICALP materials to:*

a: Academic staff-members
b: Individual students
c: Administrators

The data provided in Tables 55-1, 55-2 (pp 330 & 331), 72 (p 362), 73-1 to 73-6 (pp 366 to 377), 74 (p 381), 75-1 to 75-5 (pp 397-401), and 76 (p 405), will be used to show the effectiveness of ICALP materials to dispense anatomical information in a computer-managed learning environment. Unfortunately, precise information about definitive costs eluded the endeavours of this research project, but sufficient data were available to determine the effectiveness of computer-assisted learning materials to academic staff, individual students, and their administrators.
5.8.1 The effectiveness of ICALP to academic staff

As discussed in Chapter 3, a sequence of strategies, such as those delineated in Table 2 (p 240), may be used by academic staff to create a positive influence of ICALP learning by the majority of students. Furthermore, these procedures provide an unlimited facility for academic staff to survey the efforts of individual students whilst learning anatomy. The effectiveness of ICALP and SOCCER in a CMLE may be verified by inspection of Tables 55-1 and 55-2, 72, and 73-1 to 73-6. Overall, this information clearly demonstrates that academic staff can readily acquire sufficient data to evaluate individual and group learning efforts whilst doing so. The same information may be used to gain quantifiable data to determine the impact of any particular strategy. As described in Section 4.15, learner reaction to such strategies may be quantified by academic staff from FeedBack data, as exemplified later in Figures 163 to 180 (pp 385-395).

Such information may be continuously extracted by academic staff to verify, or reject, the validity of any stratagem during its period of evolution. In this way, sufficient information may be acquired to determine appropriate points about learning, revision, hours of effort, workstation activities, and a reasonable range of results. These data may be applied by academic staff for comparative purposes, as shown in Table 76.

A significant component of ICALP and the effectiveness of SOCCER may be determined by academic staff from data, such as that given in Table 76. In this case, a traditional scenario of anatomy teaching may be observed over a period of seven semesters, to show that 15,676 hours
spent in examinations could be expected to lead to 2,100 hours of marking at a median range of 16 minutes per two-hour paper.

The traditional scenario contrasts markedly with 7,505 hours of specific tests and 1,342 hours of mid and end of semester examinations in a CMLE throughout the same seven semester period. The outstanding benefit of the latter method, is that there is no requirement for processing and marking of examination papers, with computerized-test results immediately available after the exit of the last candidate from the CMLE.

Dependent upon the creative preference of an academic staff member, the time saved from the preparation, processing, and marking of examination papers, may be diverted to either up-date, or advance contemporaneous software. Alternatively, the time saved by SOCCER may be used to develop additional ways to empower autonomous learning, or to inaugurate the problem-based approach described in Section 4.14 (p 259).

The value of ICALP, Test-Items and SOCCER to an academic staff member may focus upon the ability to use these devices to generate a core-system of autonomous learning to empower students to work through the syllabus at their own pace, declaring their readiness to take formal, supervised, tests at preferred stages. In this way, significant numbers of students may work through essential material to meet standard requirements, whilst others may benefit from occasional rehabilitative intervention to sustain their rate of progress.
<table>
<thead>
<tr>
<th></th>
<th>Learning sessions</th>
<th>Revision sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning and revision</td>
<td>6,606</td>
<td>7,102</td>
</tr>
<tr>
<td>in the CMLE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours of effort</td>
<td>5,383</td>
<td>4,425</td>
</tr>
<tr>
<td>in the CMLE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workstation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sessions and</td>
<td>Ave clicks</td>
<td>Ave error</td>
</tr>
<tr>
<td>activities</td>
<td>Ave correct</td>
<td>Ave error</td>
</tr>
<tr>
<td>in the CMLE</td>
<td>Ave clicks</td>
<td>Ave error</td>
</tr>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICALP Learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICALP Revision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average results</td>
<td>88.16</td>
<td>89.14</td>
</tr>
</tbody>
</table>

**Table 74** Review of ICALP and CMLE activities throughout 1992 and 1993.
As exemplified by Table 74, the tedium of lecturing basic facts to UG anatomy students may be minimised, releasing valuable academic staff resources for the development of more enlightened presentation, such as problem-based learning in lecture-seminars and laboratory situations.

5.8.2 The effectiveness of ICALP to individual students

The successful use of ICALP materials by individual students is evidenced by the FeedBack facility described in Sections 3.39 and 4.15 (pp 224 & 261), amplified by the data given in Figures 170, 171, 177, 178, and 179 (pp 389-394). For example, Figure 170 illustrates responses to a question about the general level of interest in learning anatomy by computer, showing a positive response at level 4 by 82 students of the 151 surveyed (54.3%). A further 15 students registered satisfaction at level 5 (9.9%), whilst 42 appeared generally satisfied at level 3 (27.8%) with the remaining 12 recording mild dissatisfaction at level 2 (7.9%). These findings are verified by the distribution of responses to the question in Figure 171, with only 5 (3.3%) students averse to learning anatomy by a combination of Lectures, Laboratories and Computer activities. Learner reactions are equally positive in Figures 177, 178 and 179, with mean values of 3.44, 3.40 and 3.70 registered on the five point Likert-style scale mentioned in Section 3.39 (p 225).

Additional evidence of generally positive student activity is available in Appendices A to D (pp 503 to 512); Tables 55-1, 55-2, and 72 (pp 330, 331, & 362); Tables 73-1 to 73-6 (pp 366 to 377); and the distribution of effort during seven semesters between 1991 and 1994 shown in Tables 75-1 to 75-5 (pp 397-401).
The advantage of ICALP and SOCCER materials to UG and PG students of anatomy, is anchored at pretest, with unrestricted access to explore, confirm, and revise essential anatomical information. Of prime importance to individual students, is the secure knowledge that all future test items will be generated from the available learning materials. In this way, a strong bond can be established between ICALP and assessment procedures to authenticate academic staff in a secure atmosphere of self-directed problem-based learning (pp 231 to 239; Section 4.14, p 259).

The educational benefits of ICALP and SOCCER to individual students of anatomy, include an unlimited access to a wide range of repeatable, quality assured, learning materials in an interactive environment of positive reinforcement. In any formal test procedure, the same interactive processes are applied, with positive reinforcement at the end of each session, supplemented by the diagnostic advice described in Sections 3.31, 3.32, and 3.36 (pp 168, 169, & 208).

With experience, individual students may be empowered by use of these devices to select a self-paced strategy of learning to accelerate progress throughout a body of knowledge to meet personal requirements.

5.8.3 Feedback responses which demonstrate the effectiveness of ICALP to academic staff and individual students

To address the value of ICALP and CMLE activities to academic staff and individual students, the FeedBack Instrument (FBI) described in Section 4.15 (p 261) was used to acquire general and particular information from undergraduate anatomy students throughout 1992 and 1993.

Responses to questions in Figure 114 (p 227) enable the correlation of learner attitudes with subsequent results in UG2 anatomy. From this
screen it was possible to obtain quantitative information about the number of hours a week devoted to the study of anatomy, and also to measure subjective responses to specific questions.

In the same way, Figure 115 (p 228) was used to acquire responses to quantify attitudes, particular interests, and preferences, for correlation with learning styles. The same stratagems are evident in Figure 116 (p 229) to gain information about preferred learning situations, ending with an open question to facilitate unexpected information in Figure 117 (p 230).

Using these techniques, individual responses were stimulated to determine attitudes towards particular styles of learning. Such responses are provided in Appendices A to D (pp 503-512) from the anatomy populations of 1992 and 1993. Appendices A and B give most and least responses to the value of lectures; Appendices C and D give most and least responses about the value of ICALP materials.

As explained in Sections 4.7 (p 245), and 5.8.3 (p 383), the resultant data was modified for construction of Figures 163 to 180 to represent the collective feedback of the 1992 and 1993 populations. This information will be discussed briefly with implications made apparent in Appendices A to D.

Figures 163 to 165 present quantitative responses to questions related to the motivation to learn and comprehend anatomy. Responses to Figure 164 may be compared with a perception of achievement in Figure 165.
My general level of motivation to learn anatomy is ...

Figure 163. Level of motivation to learn anatomy.

My general comprehension of anatomy is ...

Figure 164. General comprehension of anatomy.

In the Figure 163 there is an obvious desire to learn anatomy with a peak of 73 responses (48.3%) at level 4, for comparison with Figure 164.
which shows a comprehension of anatomy by a peak of 88 responses (58.3%) at level 4. When these data are matched for comparison with a general level of perceived achievement of anatomy in Figure 165, there is a mean level of 3.30 with a peak of 98 responses (64.9%) at level 3.

<table>
<thead>
<tr>
<th>Resp</th>
<th>Freq</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>2.6</td>
</tr>
<tr>
<td>3</td>
<td>98</td>
<td>64.9</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>31.8</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Mean = 3.30  s.d. = 0.53
Records included: 151
Records in file: 153

My general level of achievement in anatomy is ...

Figure 165. Perceived level of achievement in anatomy.

<table>
<thead>
<tr>
<th>Resp</th>
<th>Freq</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>5.3</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>18.5</td>
</tr>
<tr>
<td>4</td>
<td>93</td>
<td>61.6</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>14.6</td>
</tr>
</tbody>
</table>

Mean = 3.85  s.d. = 0.72
Records included: 151
Records in file: 153

My general level of learning anatomy by visual imagery is...

Figure 166. Perceived learning by visual imagery.
Figures 166 to 168 identify a perceived capacity to learn anatomy by visual imagery, reading, and the completion of tasks. These responses all focus on level 4, with mean values of 3.85, 3.92, and 4.01 respectively.

The impact of visual imagery in Figure 166 is substantial, with 93 responses (61.6%). Unexpectedly, there is an apparent uniformity of responses to the perception of learning by reading and doing in Figures 167 and 168.

<table>
<thead>
<tr>
<th>Resp</th>
<th>Freq</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>23.8</td>
</tr>
<tr>
<td>4</td>
<td>73</td>
<td>48.3</td>
</tr>
<tr>
<td>5</td>
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Mean = 3.92  s.d. = 0.79

Records included: 151
Records in file: 153

My general level of learning anatomy by reading is ...

Figure 167. Perceived level of learning by reading.
My general level of learning anatomy by doing is ...

Figure 168. Perceived level of learning by doing.

Of significance to this project, the comparative responses to a perceived learning of anatomy by lectures versus computers, the findings in Figures 169 and 170 give a preference for learning anatomy by computer.

My general level of learning anatomy from lectures is ...

Figure 169. Perceived level of learning from lectures.
My general level of interest in learning by computer is ...

Figure 170. Perceived level of learning by computer.

My general desire to learn anatomy by lectures, laboratories and computers is ...

Figure 171. Desire to learn anatomy by a combination of lectures, laboratory activities, and computers.
The findings from Figures 169 and 170 are reinforced by the responses to the question in Figure 171, which show a mean of 4.13 in the desire to learn anatomy by combination of lectures, laboratories, and computers.

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Mean = 3.61  s.d. = 0.81

Records included: 151  Records in file: 153

My general ability to learn anatomy independently is ...

Figure 172. Perceived ability to learn anatomy independently.

Figure 172 compares a perceived ability to learn anatomy independently by 74 responses which peaked at level 4 (49%), with a mean of 3.61, for comparison with the results of Figure 173, showing a reduced desire to learn anatomy independently.
My general desire to learn anatomy independently is ...

Figure 173. General desire to learn anatomy independently.

The results depicted in Figure 174 show a marginal preference for learning anatomy with friends, with several who would prefer not to do so.

Of particular interest, is the profile of responses in Figure 173, which may be compared with the same question, but phrased differently, in Figure 175. In the latter case, there is a marginal preference for autonomous learning at a mean of 3.34, compared with a mean of 3.19 in Figure 173.
My preference for learning anatomy with friends is ...

Figure 174. Preference to learn anatomy with friends.

My preference for learning anatomy by myself is ...

Figure 175. Preference to learn anatomy autonomously.

As may be expected, the influence of tests whilst learning anatomy is quite evident by responses to the question in Figure 176. In this case, the majority responded at levels 4 and 5, with a mean at 3.82.
The general influence of tests upon my learn anatomy is ...

*Figure 176. The general influence of tests when learning anatomy.*

My general level of satisfaction to learn anatomy by ICALP is ...

*Figure 177. Level of satisfaction with ICALP learning.*

Response to the question related to the level of satisfaction with ICALP learning in Figure 177, shows a profile at a mean of 3.44, which is
almost replicated by the same profile with a mean level of satisfaction at 3.40 in Figure 178.

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\text{Mean = 3.40 s.d. = 0.94}

Records included: 151
Records in file: 153

\text{My general level of satisfaction with computer tests is ...}

\text{Figure 178. Level of satisfaction with tests by computer.}

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\text{Mean = 3.70 s.d. = 0.93}

Records included: 151
Records in file: 153

\text{My general level of trust in the present grading system is...}

\text{Figure 179. Level of trust in the grading system used for anatomy.}

394
Despite the thrust of the question related to the grading system in use for anatomy, Figure 179 shows a high level of acceptance with a mean at 3.70.

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Mean = 3.78  s.d. = 0.72
Records included: 151
Records in file: 153

My general level of enjoyment when learning anatomy is ...

Figure 180. General level of enjoyment when learning anatomy.

Of great significance, are the findings elicited by the question related to Figure 180, where 82 responses (54.3%) at a mean of 3.78, reveal a general level of enjoyment whilst learning anatomy.

These data, together with the information provided in Appendices A to D, may be used by academic staff and individual students to rate levels of acceptance to ICALP procedures during the development of software and problem-based strategies.

5.8.4 The effectiveness of ICALP to administrators

The advantages of ICALP and SOCCER in a CMLE may be self-evident to any tertiary administrator. The perceived task is to provide an efficient
facility of enriched resources to engender a stimulating environment of learning. The arduousness of this task is compounded by the diverse requirements of academic staff and students in a facility designed to transfer a large body of anatomical knowledge to meet the high standards of a professional qualification. To enhance the hardware on which this research project was based, software was created to meet these requirements and keep pace with the advancement of educational technology.

Apart from its learning facility, SOCCER provides an abundant database of research materials of value to an academic administrator. As mentioned in Sections 5.1.3, 5.1.4, and 5.4.1 (pp 277, 282, & 337), there is clear evidence to verify the importance of close collaboration between parallel components of a syllabus to stimulate a quality product. Evidence to this effect is demonstrated in Tables 73-1 to 73-6 (pp 366-377).

Such data, can be used to reach appropriate decisions about the most beneficial alignment of topics and themes.

For administrators, evaluation of the academic performance of individuals and groups of students in specific subject areas is of prime importance, either at pre-selection, or at other critical stages of progression. As a pre-selection device, SOCCER may be used to register responses to specific questions to quickly identify whether a candidate has met the criteria of entrance requirements. With the co-operation of accredited computer centres, such pre-selective devices may be applied to the selection of candidates, locally, at a distance, nationally, or internationally.
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Cardio-respiratory system

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Trunk & Lower Extremity

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**Trunk & Lower Extremity**

- **TrunkHip&Thigh**
  - 85 | 1360 | 125 | 173 | 53 | 123 | 306 | 53 | 118 | 195 | 67 | 85 | 62 |
- **Hip&Thigh-ICALP**
  - 77 | 541  | 86  | 33  | 32  | 93  | 40  | 38  | 74  | 32  | 36  | 42  | 35  |
- **Knee&Leg-ICALP**
  - 75 | 568  | 57  | 108 | 36  | 55  | 96  | 27  | 61  | 54  | 31  | 14  | 29  |
- **Leg&Foot-ICALP**
  - 90 | 717  | 43  | 92  | 49  | 53  | 187 | 52  | 48  | 89  | 37  | 17  | 50  |
- **LowEx-test**
  - 5  | 1134 | 137 | 124 | 78  | 136 | 131 | 94  | 126 | 122 | 86  | N/A | 100 |

**CNS**

- **AdvBrainStem**
  - 29 | 352   | N/A | 122 | 9   | N/A | 111 | 5   | N/A | 76  | 5   | 21  | 3   |
- **BrainStem&Cereb**
  - 33 | 323   | N/A | 93  | 13  | N/A | 89  | 8   | N/A | 81  | 11  | 23  | 5   |
- **CranArt&Nerves**
  - 27 | 457   | N/A | 112 | 13  | N/A | 148 | 14  | N/A | 97  | 18  | 36  | 19  |
- **HorCorBrain**
  - 24 | 340   | N/A | 89  | 8   | N/A | 93  | 8   | N/A | 68  | 13  | 53  | 8   |
- **LobSinSul&SpeCor**
  - 43 | 249   | N/A | 67  | 7   | N/A | 78  | 5   | N/A | 54  | 4   | 30  | 4   |
- **SinMen&SpeCor**
  - 32 | 304   | N/A | 83  | 12  | N/A | 80  | 5   | N/A | 77  | 8   | 35  | 4   |
- **VentLimbCaudNuc**
  - 26 | 182   | N/A | 41  | 6   | N/A | 44  | 3   | N/A | 39  | 9   | 34  | 6   |
- **Neuro-test**
  - 12 | 674   | N/A | 144 | 7   | N/A | 192 | 9   | N/A | 177 | 7   | 138 | N/A |
- **Ce'bellar-Str-ICALP**
  - 72 | 1662  | N/A | 509 | 12  | N/A | 540 | 11  | N/A | 524 | 14  | 52  | N/A |
- **Ce'bellar-FunDys-**
  - 97 | 1692  | N/A | 523 | 24  | N/A | 558 | 19  | N/A | 480 | 17  | 71  | N/A |
- **Cerebellar-test**
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<td>81</td>
<td>73</td>
<td>18</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

| EmbPerNerve-ICALP | 96 | 1314 | N/A | 322 | 28 | N/A | 420 | 34 | N/A | 222 | 5 | 238 | 45 |
| EmbPerNerve-test  | 4  | 394  | N/A | 72  | 33 | N/A | 87  | 39 | N/A | 57  | 32 | 37  | 37 |
| Nerve-ICALP       | 120 | 2495 | N/A | 618 | 59 | N/A | 646 | 76 | N/A | 685 | 92 | 251 | 68 |
| Nerve-test        | 6  | 514  | N/A | 83  | 46 | N/A | 90  | 42 | N/A | 81  | 37 | 92  | 43 |
| BraPlexus-ICALP   | 44  | 468  | N/A | 76  | 18 | N/A | 97  | 35 | N/A | 111 | 26 | 83  | 22 |
| BraPlexus-test    | 4  | 141  | N/A | 31  | 13 | N/A | 36  | 9  | N/A | 41  | 11 | N/A | N/A |
| Reflex-ICALP      | 81  | 1101 | N/A | 364 | 29 | N/A | 223 | 24 | N/A | 306 | 28 | 101 | 26 |
| Reflex-test       | 5  | 296  | N/A | 72  | 16 | N/A | 57  | 18 | N/A | 69  | 12 | 31  | 21 |
| Reflex-TFTI       | 6  | 150  | N/A | 20  | 14 | N/A | 21  | 23 | N/A | 19  | 9  | 21  | 23 |
| NerveReflex-test  | 4  | 125  | N/A | 27  | 6  | N/A | 36  | 8  | N/A | 42  | 6  | N/A | N/A |

| Pathology        |               |               | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | 163 | 42  | 119 | 47 |
| BonePath-ICALP   | 38  | 371  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | 163 | 42  | 119 | 47 |
| GeneticPath-ICALP| 42  | 172  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | 107 | 29  | 4   | 32 |
| EndoPath-ICALP   | 75  | 155  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | 97  | 22  | 8   | 28 |
| OncoPath-ICALP   | 58  | 165  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | 121 | 18  | 3   | 23 |
| Comp-E-Track     | 13  | 62   | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | NYD  | 25  | 12  | 25  | N/A|

| Mid-semester tests | 5  | 685  | 121  | 97  | N/A | 112 | 102 | N/A | 53  | 94  | N/A | 106 | N/A |
| End-semester tests | 5  | 657  | 117  | 93  | N/A | 108 | 97  | N/A | 49  | 91  | N/A | 102 | N/A |
|-----------------------------|-------------------|------|------|------|------|------|------|------|------|------|------|------|
| Semester I                  | (hrs)             | 83   | 85   | 37   | 81   | 82   | 59   | N/A  | 73   | 42   | 78   | 43   |
| Semester II                 | (hrs)             | 83   | 85   | 21   | 81   | 82   | 17   | 81   | 73   | 18   | N/A  | N/A  |
| Total hours                 |                   | 2,620| 34,492| 1,701| 6,287| 1,123| 1,978| 6,707| 1,198| 1,220| 7,485| 1,529| 3,594| 1,670|


- 25 workstations open from 7.30 AM to 8.00 PM
- Workstation hours per day: 25 x 12.5 hrs
- Workstation days per 5 day week: 312.5 hrs
- Workstation hours per 14 week semester: 1,562.5 hrs
- Workstation hours per 28 week academic year: 43,750.0 hrs
- Workstation hours from semester I, 1991 to end of semester I, 1994: 153,125.0 hrs

Key

N/A: Not applied
NYD: Not yet developed
UG: Undergraduates
PG: Postgraduates
Furthermore, should a candidate propose a transfer from one academic institution to another, objective questions may be administered to equate the level of competence of an entrant for appropriate placement into the incoming syllabus. In addition, should a candidate be preferred, ICALP and other test items in SOCCER, may provide self-paced learning activities to rectify any inter-institutional differences, or accelerate the rate of advancement of an entrant to meet local standards.

At an administrative level, SOCCER may be used to ensure that sufficient information is readily available to assess the comparative rate of success by one cohort with another, as shown in Tables 73-1 to 73-6, and Tables 75-1 to 75-5, or to make comparative diagnostic predictions of individual ability from established patterns of learning behaviour, as outlined in Figure 105 (p 219).

It would seem of equal importance to an academic administrator, to be provided with a rapid facility from which to determine the quality assurance of any educational method in use, as well as to speedily evaluate the effectiveness of any academic staff member who is responsible for such presentation. Quality assurance data would be readily available from SOCCER at all times, with an option to extract responses to the FeedBack mechanism described in Sections 3.39 and 4.15 (pp 224 & 261). Such quantitative information may be rapidly retrieved via the techniques shown in Figures 163 to 180 (pp 385-395), for correlation with qualitative remarks, such as those shown in Appendices A to D (pp 503 to 512).

Although precise cost-benefits proved to be obscure to this project, the principles may be applied to determine a progressive view of learning
and revision activities, as in Tables 55-1, 55-2 (pp 330 & 331), with results in Tables 72 and 73-1 to 73-6 (pp 362-377) to construct an overview of usage, as in Table 74 (p 381). Furthermore, of import to an academic administrator, would be the facility to construct an account of the hours of effort devoted to particular aspects of learning, as in Tables 75-1 to 75-5 (pp 397-401), for reconstruction to provide comparative data between regimes of study, as in Table 76 (p 405).

The traditional and computer-assisted cases presented in Table 76, may be effectively used by an administrator to determine the advantages and disadvantages of each method. Disregarding the need for an end of semester formal examination paper, Table 76 demonstrates over a period of seven semesters, that a traditional environment requires: 56 hours of examination preparation; 15,676 student examination hours; a minimum of 31,504 examination question pages; at least 15,752 8-page examination booklets; and an expenditure of 2,100 academic staff-hours to grade examination papers. If it is accepted that formal middle and end of semester written-practical examinations are not required, then the above costs and staff-time expenditure may be reduced by 50%.

The major detraction of a CMLE is the constant need to provide, service, and upgrade a network of workstations, with sufficient funds to replace obsolete units. If accepted, the cost-benefits of this educational philosophy may be applied to support the cost-effectiveness of such an enterprise.

For the purposes of this project, it is important to point out that during its seven semester period of operation, the workstation availability of the CMLE was some 153,125 hours of duration, in which some 803 UG and
PG anatomical students devoted 34,492 hours of personal time to the study of anatomy. Notwithstanding that 9,808 hours of this effort was outside that formally set aside for the study of anatomy, as may be seen by the time devoted to learning and revision in Table 74, the overall proportion of effort by UG and PG anatomy students was 22.52% of that expected of them. Firstly, the implication of these findings suggest a cost-benefit of over 75% to individual students using ICALP techniques, and secondly, that such savings could be investigated by administrators for the introduction of advanced curricula.

In the traditional scenario shown in Table 76, the expected student hours of self study proved to be 782,992 hours for the 803 UG and PG students of anatomy between 1991 and 1994. The acknowledged period of self-study was dispersed between library and home-studies. For the CMLE component, it may be perceived that either 34,492 of expected hours was set aside for computer-assisted learning, or that its mere presence resulted in a boost to individual student cost-effectiveness.

Evidence in support of personal cost-effectiveness from ICALP studies, may be seen from the declared number of hours spent per week in the study of anatomy in Figure 114 (p 227). From this feedback question, the average estimate was 4.52 hours per week whilst learning anatomy in 1992, with an average of 5.34 hours estimated per week in 1993. These results are averaged at 4.93 hours per week for the 803 participants of this project during 98 weeks of operation, amounting to a declared total of 387,961 hours of self-paced study, for comparison with an expected total of 782,992 hours for the same purpose.
### Table 76. Comparison of a traditional lecture-examination environment with a 25 workstation CMLE throughout 98 weeks of instruction from the beginning of Semester-I, 1991 to the end of Semester-I, 1994.

**A traditional lecture-examination environment**

<table>
<thead>
<tr>
<th>Number of UG &amp; PG students</th>
<th>Number of lecture hours</th>
<th>Staff hrs of lecture prep’n</th>
<th>Expected student hrs of self study</th>
<th>Staff hrs of exam prep’n</th>
<th>Number of exam hours</th>
<th>No of A4 exam’n &quot;Q&quot; pages</th>
<th>No of A4 marking at exam books</th>
<th>Total hrs marking at 16min p.paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG1: 249</td>
<td>280</td>
<td>280x2</td>
<td>249x280x2</td>
<td>20</td>
<td>5180</td>
<td>249x10x4</td>
<td>249x10x2</td>
<td>249x10x16/60</td>
</tr>
<tr>
<td>UG2: 317</td>
<td>588</td>
<td>588x2</td>
<td>312x588x2</td>
<td>28</td>
<td>8736</td>
<td>317x14x4</td>
<td>317x14x2</td>
<td>317x14x16/60</td>
</tr>
<tr>
<td>PG: 237</td>
<td>616</td>
<td>616x2</td>
<td>220x616x2</td>
<td>8</td>
<td>1760</td>
<td>237x4x4</td>
<td>237x4x2</td>
<td>237x4x16/60</td>
</tr>
<tr>
<td><strong>Totals:</strong></td>
<td><strong>1,484</strong></td>
<td><strong>2,968</strong></td>
<td><strong>782,992</strong></td>
<td><strong>56</strong></td>
<td><strong>15,676</strong></td>
<td><strong>31,504</strong></td>
<td><strong>15,752</strong></td>
<td><strong>21,100</strong></td>
</tr>
</tbody>
</table>

**A comparable 25 workstation CMLE situation**

<table>
<thead>
<tr>
<th>Hours of software dev’t</th>
<th>Hours of CMLE use</th>
<th>UG hours in CMLE</th>
<th>PG hours in CMLE</th>
<th>Hours of SOCCER use</th>
<th>Hours of learning in CMLE</th>
<th>Hours of specific tests</th>
<th>Hours in mid &amp; end of Sem exam’n</th>
<th>Hours in FeedBack sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,620</td>
<td>34.492</td>
<td>28.972</td>
<td>5,520</td>
<td>596</td>
<td>24,991</td>
<td>7,505</td>
<td>1,342</td>
<td>58</td>
</tr>
</tbody>
</table>

**Appropriation of costs to maintain 25 workstations for 98 weeks of anatomical learning from 1991 to 1994**

<table>
<thead>
<tr>
<th>Original hardware acquisition</th>
<th>Annual network costs</th>
<th>Annual maint’ce costs</th>
<th>Workst’n hrs per day</th>
<th>Workst’n hours per 5 day wk</th>
<th>Workst’n hours per 14 wk Sem</th>
<th>Workst’n hours per 28 wk year</th>
<th>Workst’n availability</th>
<th>CMLE use for anatomy</th>
<th>7 Sem 91-94</th>
<th>7 Sem 91-94</th>
</tr>
</thead>
<tbody>
<tr>
<td>A$32,000</td>
<td>Not available</td>
<td>312.5</td>
<td>1,563</td>
<td>21.875</td>
<td>43.750</td>
<td>153.125</td>
<td>34.492</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
These data show the declared rate to be 50.45\% of the expected rate, representing a personal cost-saving of 395,031 hours of effort in 98 weeks of undergraduate studies in anatomy, which may be construed from Table 76.

At a sundry, or consumable level, with the advent of SOCCER and presence of Image-Writer printers in the CMLE, the problem-based learning questions (pp 232-239) were dispensed to cause individual students to print these problems at their own expense, saving administrative costs and reams of photocopied paper.

The implications of these statements would need to be carefully considered by the administrators of any similar operation.

5.8.5 Affirmation of the subsidiary research conclusions
From the data and discussions undertaken via Sections 5.8.1, 5.8.2, and 5.8.3, it is now possible to state that:

*These research results affirm the relative cost-effectiveness of ICALP materials to academic staff-members, individual students, and administrators for the presentation of anatomical studies to tertiary students*
5.9 Additional findings

Subsequent to the analyses and conclusions of the previous sections of this chapter, it was considered important to verify the retention of excellence in anatomical studies by the research populations of 1992 and 1993. Furthermore, by virtue of the feedback instrument mentioned in Sections 3.39, 4.15, and 5.10, sufficient information was derived to resolve a supplementary research question regarding pre-entry qualities of education which may predict the outcome of tertiary studies in anatomy.

5.9.1 Retention of academic excellence in 1992 and 1993

To verify the maintenance of a satisfactory standard of academic excellence, the end of year achievements of UG1 students of anatomy in 1991 were compared with the UG2 results from the same subject at the end of 1992. The mean values of raw scores are presented in Figure 181 and Table 77. In the same way, the end of year anatomical results of the UG1 population of 1992 are compared with UG2 results at the end of 1993. This information is given in Figure 182 and Table 78.

In a situation of repeated measures, Table 77 confirmed the presentation in Figure 181, to show a remarkable degree of uniformity during progression from the end of UG1 in 1991 to their final achievements at UG2 in 1992. The mean comparative results at the end of UG1 (70.19%) with results at the end of UG2 (70.78%), together with standard deviations of 5.80 and 5.81 respectively, confirm that no adverse effects may be attributed to the intervention of ICALP materials and research methods applied during the 1991-1992 period.
Figure 181. Comparison of UG1 and UG2 results 1991-92.

Table 77. Comparison of end of year anatomy results between UG1 1991 with UG2 1992.

End of year anatomy test means table.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X (%)</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG1 results 1991</td>
<td>79</td>
<td>70.19</td>
<td>5.80</td>
</tr>
<tr>
<td>UG2 results 1992</td>
<td>79</td>
<td>70.78</td>
<td>5.81</td>
</tr>
</tbody>
</table>
Figure 182. Comparison of UG1 and UG2 results 1992-93.

Table 78. Comparison of end of year anatomy results between UG1 1992 with UG2 1993.

End of year anatomy test
means table.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>X (%)</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG1 results 1992</td>
<td>73</td>
<td>65.13</td>
<td>5.78</td>
</tr>
<tr>
<td>UG2 results 1993</td>
<td>73</td>
<td>69.10</td>
<td>4.63</td>
</tr>
</tbody>
</table>
The same technique of repeated measures are provided Table 78 to confirm the presentation in Figure 182.

However, the latter results show a minor disunity of progression at the end of UG1 in 1992 to the level of performance in UG2 at the end of 1993. The mean comparative values at the end of UG1 (65.13%) with results at the end of UG2 (69.10%), alongside standard deviations of 5.78 and 4.63 respectively, display an advancement of the cohort at the end of UG1 and UG2, confirming that no adverse effects may be attributed to the intervention of ICALP and research methods in the 1992-1993 period. Furthermore, it is presumed that the beneficial differences exhibited by the UG2 population in 1993, may be awarded to the advent of SOCCER in that academic year.

The fractional range of differences in Tables 77 and 78 are emphasised by the distributions in Figures 181, and 182. In this format, there are no observable differences between the group embedded figures test (GEFT) results from the end of UG1 in 1991 to the end of UG2 in 1993. However, review of the remaining content of Figure 181 shows a high level of homogeneity, with a range of differences of 25.02% at the end of UG1 and 26.08% at the end of UG2.

Apart from a uniformity of GEFT scores in Figure 182, considerable differences may be observed around the mean of 65.13% at the end of UG1 in 1992, with the final mean of 69.10% at the end of UG2 in 1993. However, the range of differences is reduced from 29.34% at the end of UG1 to 25.43% at the end of UG2. This is reflected by minima of 52.71% and 58.82% against maxima of 82.05% and 84.25% respectively in Figure 182, confirmed by the mean values shown in Table 78.
These respective data, are applied to confirm that no harm came to either of the anatomical research populations throughout 1992 or 1993.

5.9.2 An unexpected EEHB-MCP supplementary research question
As expressed in Chapter 2, Sections 2.7 (p 20), 2.24 (p 81), and 2.41 (p 127), the influence of examination criteria for the pre-selection of tertiary students is of prime importance. Consequently, it became of interest to investigate the relationship between pre-entry scores and subsequent achievements in the study of anatomy.

From the observations described in Section 3.1 (p 130) regarding a widely held view by the academic community and schools of anatomy dealing with the education of medical and physiotherapy students:

that high ranking students of English, English Literature and Human Biology, are more likely to be able to transpose 2-D anatomical information into a 3-D anatomical skill than equally high achievers in Mathematics, Chemistry and Physics.

It was decided to use the feedback instrument (Sections 3.39, 4.15, & 5.10) to resolve this important supplementary research question.

Sufficient information was derived from responses to the questions shown in Figure 113 (p 226) to equate pre-entry achievements in English, English Literature, and Human Biology (EEHB), and Mathematics, Chemistry, and Physics (MCP), for comparison with the outcome of anatomy studies at the end of UG2 in 1992 and 1993.
To meet these requirements, the 1991 and 1992 UG1 populations were categorised into EEHB and MCP groups for comparison with their respective 2-D and 3-D UG2 achievements at the end of 1992 and 1993.

To determine any intrinsic differences of 2-D anatomical achievement, Table 79 was applied to illustrate the mean values of the EEHB and MCP categories at pre-entry to UG1 studies in 1991. Table 80 was used to demonstrate the mean achievements of the same groups on exit from UG2 anatomical studies in 1992.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>EEHB</td>
<td>39</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>0.354</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation ratio</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
<td>$F = 2.356$ $P = 0.129$</td>
</tr>
</tbody>
</table>

Table 79 shows a close conformity of values on entry in favour of the EEHB group, with an effect size of 0.354 and correlation ratio of 0.033. On exit from UG2 anatomical studies in 1992, Table 80 shows a close conformity of performance by both groups, with a reduced effect size of -0.054 and correlation ratio of 0.025.
Table 80. EEHB-MCP posttest results in anatomy at the end of UG2 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$\bar{x}$</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEHB</td>
<td>39</td>
<td>70.32</td>
<td>4.88</td>
<td>1</td>
<td>56.504</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>70.68</td>
<td>6.69</td>
<td>66</td>
<td>2195.614</td>
</tr>
</tbody>
</table>

**Significance**

- Effect size (ESI) - 0.054
- Correlation ratio 0.025
- Probability $F = 0.566$ $P = 0.639$

The data in Table 79 and 80 are compared by ANCOVA in Table 79-80, showing the MCP category to possess a fractional adjusted advantage.

Table 79-80. ANCOVA of EEHB-MCP achievements on pre-entry to UG1 1991 with final anatomy results at UG2 1992.

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-entry results in EEHBMCP</td>
<td>Final results in UG2 anatomy</td>
</tr>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>-------</td>
<td>---</td>
</tr>
<tr>
<td>EEHB</td>
<td>39</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
</tr>
</tbody>
</table>

In the same way Table 81 illustrates the mean values of 2-D results by the EEHB and MCP categories at pre-entry to UG1 studies in 1992. Whereas Table 82 demonstrates the achievements of the same groups on exit from UG2 anatomical studies in 1993.

In this case, Table 81 shows discordant mean values on entry which favour the MCP group, with an elevated effect size of -0.610 and correlation ratio of 0.062.
Table 81. EEHB-MCP pre-entry UG1 results of the 1992 cohort.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>( \bar{X} )</td>
</tr>
<tr>
<td>EEHB</td>
<td>35</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.610</td>
<td>0.062</td>
<td>F = 4.243 P = 0.043</td>
</tr>
</tbody>
</table>

However, on exit from UG2 anatomical studies in 1993, the same categories show a remarkable unity of performance in Table 80, with a reduced effect size of 0.087 and correlation ratio of 0.045.

Table 82. EEHB-MCP posttest results in anatomy at the end of UG2 1993

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>( \bar{X} )</td>
</tr>
<tr>
<td>EEHB</td>
<td>35</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.087</td>
<td>0.045</td>
<td>F = 0.981 P = 0.408</td>
</tr>
</tbody>
</table>

These data are affirmed by ANCOVA in Table 81-82, to show the EEHB category with a fractional advantage of adjusted scores.
Table 81-82. ANCOVA of EEHB-MCP achievements on pre-entry to UG1 1992 with final anatomy results at UG2 1993.

<table>
<thead>
<tr>
<th>Control-variable</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-entry results in EEHBMCP</td>
<td>Final results in UG2 anatomy</td>
</tr>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>EEHB</td>
<td>35</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
</tr>
</tbody>
</table>

From these results, it is clear that neither the EEHB nor the MCP categories of pre-entrants to UG1 students in 1991 and 1992, held any intrinsic academic qualities which may be applied to predict the outcome of success in 2-D anatomical studies at the end of UG2 in 1992 and 1993 respectively.

Table 83. EEHB-MCP CTR 3-D pretest of the 1991 UG1 cohort.

<table>
<thead>
<tr>
<th>Means table</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>EEHB</td>
<td>39</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>Correlation ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.175</td>
<td>0.033</td>
<td>F = 0.753</td>
</tr>
</tbody>
</table>

To determine if any potential differences of 3-D ability may be held by the EEHB and MCP categories of UG1 entrants in 1991 and 1992, the comparative methods used above were applied for correlation with
CTRS and CNS 3-D anatomical scores at the UG2 level in 1992 and 1993 respectively.

The pretest 3-D CTRS abilities of the EEHB and MCP categories from the UG1 entrants in 1991 are given in Table 83. Whereas Table 84 illustrates the posttest achievements of the same groups on exit from 3-D CTRS studies at the UG2 level in 1992, Table 83 shows a conformity of mean values at CTRS 3-D pretest which favour the MCP group, with raised standard deviations, moderated by an effect size of -0.175 and correlation ratio of 0.033. On exit from CTRS 3-D UG2 studies in 1992, Table 84 shows a uniform performance by both groups, still in favour of the MCP group, with more acceptable standard deviation values, but a mildly elevated effect size of -0.224 and a reduced correlation ratio of 0.016.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEHB</td>
<td>39</td>
<td>73.00</td>
<td>7.99</td>
<td>1</td>
<td>58.151</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>74.73</td>
<td>6.76</td>
<td>66</td>
<td>3541.460</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Effect size (ESI)</th>
<th>-0.224</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation ratio</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>Probability</td>
<td>( F = 0.361 ) ( P = 0.781 )</td>
</tr>
</tbody>
</table>

These data are confirmed by regression analysis in Table 83-84, to show a fractional advantage to the MCP category within adjusted scores.
Table 83-84. ANCOVA of EEHB-MCP CTR 3-D pretest of the 1991 cohort and at posttest in UG2 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Pretest achievement</th>
<th>Posttest adjusted</th>
<th>Posttest unadjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEHB</td>
<td>39</td>
<td>69.18</td>
<td>73.39</td>
<td>73.00</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>70.91</td>
<td>74.34</td>
<td>74.73</td>
</tr>
</tbody>
</table>

To elucidate the EEHB-MCP CTR question further in 1992, the results of the respective subcategories of the UG2 population were viewed by box plot in Figure 183.

![Box plot](image)

Figure 183. EEHB-MCP CTR 3-D pre-posttests at UG2 in 1992.

At pretest in 1992, it will be observed that both categories of the UG2 population were already well advanced in studies of the cardio-thoracic system, shown by a tight formation of box and whiskers by the EEHB and MCP categories. With the exception of one outlier immediately below the lower whisker, the advantage at posttest appears to be held by
the MCP group. However, on close inspection, the median of the EEHB category lies at 72% compared with 71.5% shown by the MCP group. At posttest, the EEHB category demonstrates a marginal improvement overall, with no change of the upper whisker at 87%, but an elevation of box, median, and lower whisker. In this instance, the advantage appears to go to the MCP category, with two inferior outliers, and an even distribution of box and whiskers, with a median presentation at 77%.

The pretest 3-D CTRS abilities of the EEHB and MCP categories from the UG1 entrants in 1992 are given in Table 85. Whilst Table 86 illustrates the posttest achievements of the same groups on exit from 3-D CTRS studies at the UG2 level in 1993.

<table>
<thead>
<tr>
<th>Table 85. EEHB-MCP CTR 3-D pretest of the 1992 UG1 cohort.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means table</strong></td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>EEHB</td>
</tr>
<tr>
<td>MCP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect size (ESI)</td>
<td>0.128</td>
</tr>
<tr>
<td>Correlation ratio</td>
<td>0.045</td>
</tr>
<tr>
<td>Probability</td>
<td>F = 0.975  P = 0.410</td>
</tr>
</tbody>
</table>

Table 85 shows a conformity of mean values at CTRS 3-D pretest which are slightly in favour of the MCP group, with a satisfactory conformity of low standard deviation values, with a low effect size of 0.128 and correlation ratio of 0.045. On exit from CTRS 3-D UG2 studies in 1993, Table 86 shows an advanced performance in favour of the EEHB group,
with alarming standard deviations from both groups, ameliorated by an effect size of -0.050 and a reduced correlation ratio of 0.012.

| Table 86. EEHB-MCP CTR 3-D posttest of the 1992 cohort at UG2 1993. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| | Means table | Analysis of variance |
| | Group  | n  | X  | s.d. | df | Sum of Squares |
| | EEHB   | 35 | 79.05 | 18.67 | 1 | 268.192 |
| | MCP    | 31 | 77.42 | 19.03 | 62 | 22595.086 |
| Significance | Effect size (ESI) | - 0.050 |
| | Correlation ratio | 0.012 |
| | Probability | F = 0.245 P = 0.864 |

These data are confirmed in Table 85-86, showing advantage to the EEHB category throughout.

| Table 85-86. ANCOVA of EEHB-MCP CTR 3-D pretest of the 1992 cohort and at posttest in UG2 1993. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| | Control-variable | Criterion-variable |
| | Pretest | Posttest |
| | Group  | n  | achievement | adjusted | unadjusted |
| | EEHB   | 35 | 21.91 | 79.03 | 79.05 |
| | MCP    | 31 | 22.23 | 77.52 | 77.42 |

To review the UG2 CTR 3-D complex in 1993, a box plot strategy was applied to create Figure 184. In this case, both elements demonstrate a naive, or inexperienced, formation with a median of 22.5% from the EEHB category and 23% from the MCP group. It is of interest to note
the two outliers surrounding the MCP category at pretest, with one above at 37.5%, and one below at 15%.

![Box plot showing pretest and posttest EEHB and MCP scores.](image)

**Figure 184. EEHB-MCP CTR 3-D pre-posttests at UG2 in 1993.**

At posttest, the MCP category shows a remarkable improvement with the upper whisker reaching the 100% boundary, with a median of 82.5% set at the upper margin of the box, and no lower whisker. Of further interest, are two outliers below the MCP deployment at posttest, one at 37.5%, the other at 18%. Of concern is that the lowest MCP individual presented at 15% in the pretest. The posttest presentation by the EEHB group for CTR 3-D studies in 1993 is more conventional, with the upper whisker up to the 100% boundary and a median of 83%. However, the box width ranges from 92% down to 67.5%, with the lower whisker at 50%. These results verify the alarming standard deviation distribution shown in Table 86. Nevertheless, overall, the advantage appears to go to the EEHB UG2 group in 1993.
The same methods were used to compare pre and posttest 3-D CNS abilities of the EEHB and MCP categories throughout 1991 and 1993. Table 87 serves to illustrate the CNS 3-D abilities of the UG1 entrants in 1991, whereas Table 88 depicts the posttest achievements of the same groups on exit from 3-D CNS studies at the UG2 level in 1992.

Table 87. EEHB-MCP CNS 3-D pretest of the 1991 UG1 cohort.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEHB</td>
<td>39</td>
<td>41.85</td>
<td>8.47</td>
<td>1</td>
<td>461.935</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>42.35</td>
<td>9.90</td>
<td>66</td>
<td>3763.208</td>
</tr>
</tbody>
</table>

Significance:
- Effect size (ESI) 0.087
- Correlation ratio 0.109
- Probability \( F = 2.701 \) \( P = 0.052 \)


<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEHB</td>
<td>39</td>
<td>83.95</td>
<td>10.50</td>
<td>1</td>
<td>24.688</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>82.68</td>
<td>9.71</td>
<td>65</td>
<td>6174.183</td>
</tr>
</tbody>
</table>

Significance:
- Effect size (ESI) 0.053
- Correlation ratio 0.004
- Probability \( F = 0.088 \) \( P = 0.966 \)
Table 87 indicates uniform mean values at pretest which favour the MCP group, and a low effect size of 0.087 and elevated correlation ratio of 0.109. On exit from CNS 3-D UG2 studies in 1992, Table 88 shows a uniform performance by both groups, which favours the EEHB group, with a slight elevation of standard deviation, but decreased effect size of 0.053 and a reduced correlation ratio of 0.004.

These data are confirmed by regression analysis in Table 87-88, showing an advantage to the EEHB category throughout.

<table>
<thead>
<tr>
<th>Table 87-88. ANCOVA of EEHB-MCP CNS 3-D pretest of the 1991 cohort and at posttest in UG2 1992.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control-variable</td>
</tr>
<tr>
<td>Pretest</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>EEHB</td>
</tr>
<tr>
<td>MCP</td>
</tr>
</tbody>
</table>

To investigate the EEHB-MCP CNS 3-D UG2 studies in 1992, a box plot distribution was applied to form Figure 185. At pretest, the EEHB category shows a range of box and whiskers between 59.5% and 27%, with a median at 40%. With the exception of one brilliant outlier at 80%, the MCP category shows a more compact display, ranging between 52.5% and 28%, with a median at 41.5%.

At posttest, both categories show extraneous outliers below the lower whisker. With those exceptions, both groups display a satisfactory elevation, with the advantage to the EEHB category showing a median of 87% compared with a median of 83% from the MCP group.
In the same way, the pretest 3-D CNS abilities of the EEHB and MCP categories UG1 entrants in 1992 are given in Table 89. Whilst Table 90 serves to illustrate the posttest achievements of the same groups on exit from 3-D CNS studies at UG2 in 1993.

**Table 89. EEHB-MCP CNS 3-D pretest of the 1992 UG1 cohort.**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEHB</td>
<td>35</td>
<td>38.43</td>
<td>7.66</td>
<td>1</td>
<td>391.038</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>42.06</td>
<td>7.55</td>
<td>62</td>
<td>3507.826</td>
</tr>
</tbody>
</table>

Significance: Effect size (ESI) = -0.053, Correlation ratio = 0.100, Probability = F = 2.304, P = 0.086
Table 89 shows a discrepancy of values at pretest which distinctly favour the MCP group, with a conformity of standard deviations, and a low effect size of -0.053 alongside a correlation ratio of 0.100. Nevertheless, the discrepant pretest situation was modified at posttest in Table 90, which reveals a uniform performance mildly in favour of the MCP group, with a conformity of standard deviations and slightly elevated effect size of -0.255, but reduced correlation ratio of 0.019.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>( \bar{X} )</th>
<th>s.d.</th>
<th>df</th>
<th>Sum of Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEHB</td>
<td>35</td>
<td>66.45</td>
<td>6.91</td>
<td>1</td>
<td>58.672</td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>67.39</td>
<td>7.12</td>
<td>62</td>
<td>3090.807</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Significance</th>
<th>Analysis of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect size (ESI)</td>
<td>-0.255</td>
</tr>
<tr>
<td>Correlation ratio</td>
<td>0.019</td>
</tr>
<tr>
<td>Probability</td>
<td>F = 0.392 ( P = 0.759 )</td>
</tr>
</tbody>
</table>

These data are confirmed by regression analysis in Table 89-90, to show a retained fractional advantage to the MCP category overall.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>achievement</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Criterion-variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>adjusted</td>
</tr>
<tr>
<td>EEHB</td>
<td>35</td>
<td>38.43</td>
<td>66.78</td>
<td>66.45</td>
<td></td>
</tr>
<tr>
<td>MCP</td>
<td>31</td>
<td>42.06</td>
<td>67.30</td>
<td>67.39</td>
<td></td>
</tr>
</tbody>
</table>
The range of differences displayed by the UG2 EEHB-MCP CNS 3-D categories in 1993 are shown by Figure 186. In this situation at pretest, the advantage appears to favour the MCP category. However, at posttest, the MCP group displays an elevated format, with no outliers and a median of 66%. In the case of the EEHB category, although the upper whisker is five points below the MCP group, the lower whisker of the EEHB category is four points above that of the MCP group. Furthermore, although the box of the EEHB category is marginally lower than that of the MCP group, the EEHB category obtained a median of 68% compared with a median of 66% from the MCP group.

![Figure 186. EEHB-MCP CNS 3-D pre-posttests at UG2 in 1993.](image)

From these results, it is clear that neither the EEHB nor the MCP categories of pre-entrants to UG1 students in 1991 and 1992, held any intrinsic academic qualities which may be applied to predict the outcome of success in either 2-D or 3-D anatomical studies at the end of UG2 in 1992 and 1993 respectively.
5.9.3 Supplementary EEHB-MCP research conclusion

From the foregoing analyses, apart from marginal differences of no statistical significance, it can now be declared:

*that there are no discernible qualitative or quantitative group differences by which to predict that an inherent ability may be held by high ranking pre-entrant achievers in English, English Literature, Human Biology, Mathematics, Chemistry, or Physics, to transpose 2-D anatomical information into a 3-D skill at the end of the second year of undergraduate anatomy studies.*

5.10 Summary of additional findings

By evidence gained to reach the primary and first part of the secondary research conclusions in Sections 5.3.1 and 5.6.1 (pp 335 & 364), sufficient data were obtained to verify the retention of excellence in anatomical studies throughout 1992 and 1993. These data are given in Figures 181 and 182, and Tables 77 and 78, to compare GEFT scores with a full range of information derived from the UG1 and UG2 populations of 1992 and 1993.

From this evidence, it is clear that neither of the two research populations suffered any detrimental effects during the two years of intense research activity. Furthermore, these findings support the continued use of ICALP and SOCCER to augment formal lectures in anatomy with a problem-based approach to self-paced learning.

Using unexpected data derived from questions applied by the FeedBack Instrument, it became possible to address observations made in Sections
2.7 (p 20), 2.24 (p 81), 2.41 (p 127), and 3.1 (p 130). In essence, these observations entailed an evaluation of differences between high ranking pre-entrants in English, English Literature, Human Biology, Mathematics, Chemistry, or Physics, and their ability to transpose 2-D anatomical information into a 3-D skill.

Overall, these data verify that no qualitative or quantitative differences are possessed by EEHB or MCP pre-entrants which may be used to predict the outcome of success by either category in undergraduate studies of anatomy.
CHAPTER 6

DISCUSSION

The primary aim of this study was to validate the use of computer-assisted learning packages dispensed by SOCCER (self operated computer controlled educational resource) to undergraduate (UG) physiotherapy students of anatomy. To meet this challenge, the coincidental availability of computer driven software was applied to supplement and replace traditional lectures in anatomy. Although the educational value of computerized learning may be self-evident, there was a distinct need to verify its use by a well researched course of investigation.

To quantitatively investigate the hypothesis that ICALP (interactive computer-assisted learning packages) techniques can be as effective as traditional lectures for the education of physiotherapy students in anatomy, sufficient ICALP and supporting software were developed to provide ten definitive areas of learning. Initially, a pilot study was undertaken in 1989-90 to establish the process, followed by the development of quality assured software for the UG population in anatomy during 1991. Throughout 1992, the UG anatomy population was randomly subdivided into Lecture and ICALP groups, to the mutual exclusion of each to the other, in ten discrete areas of learning. To avoid any risk of Hawthorne Effect, the Lecture-ICALP roles were interchanged at prescribed intervals. To validate these results, the same process was applied in the same way to the succeeding population in 1993.
The secondary aim of this study was to identify the influence of ICALP materials upon the acquisition of 2-D cognitive anatomical information and the ability to transfer it into a 3-D psycho-motor skill.

A subsidiary aim of this study was to review the accumulated data to compare the educational and administrative cost-effectiveness of ICALP and SOCCER for comparison with traditional lectures for the teaching and learning of anatomy at the tertiary level. Ample evidence has been given in Chapter 5 to affirm the effectiveness of ICALP and SOCCER in 2-D experiments. Also, sufficient evidence is given to verify the use of ICALP techniques for the conversion of 2-D anatomical information into a 3-D skill. Furthermore, from the accumulated results of this thesis, it is possible to affirm the cost-benefits of ICALP and SOCCER to academic staff, individual students and academic administrators.

During the administration of the FeedBack Instrument, sufficient data was obtained to deny the presence of an ability held by high ranking pre-entrants in English, English Literature, and Human Biology (EEHB) or Mathematics, Chemistry, and Physics (MCP) to more readily transpose 2-D information into a 3-D anatomical skill. The consequence of high achieving EEHB and MCP entrants at pre-selection with outcomes in anatomy is also discussed, together with the benefits of student feedback from the populations of 1992 and 1993. The limitations, significance, and recommendations of this study are presented in the closing paragraphs of this chapter.
6.1 Effectiveness of ICALP and SOCCER to empower student autonomy in anatomy

The collective 2-D data in Sections 5.1.1 to 5.1.10 (pp 267-323), summarised in Section 5.2 (p 328), alongside 3-D data in Sections 5.4.1 to 5.4.3 (pp 337-351) summarised in Section 5.5, were derived from the 1992 and 1993 undergraduate populations in anatomy to resolve the primary and secondary research conclusions in Sections 5.3 and 5.6 (pp 334 & 363).

Although obvious comparisons can be made about the relative differences on entry and exit of the 1992 and 1993 populations in anatomy, ample data from the CMLE (computer-managed learning environment) were used to explore pre and posttest results by ANOVA to identify between and within-group differences, effect size estimators, variance, and correlation ratios. These data are verified by boxplot in cardio-respiratory, upper extremity, and central nervous system experiments, whilst the same information was used to delineate results by regression studies and ANCOVA to eliminate the risk of sampling error, as well as to identify any variation between groups.

Meta-analysis was applied to standardise effect size results to determine any main, or treatment effects, which may influence the outcome of the experiments used in this project. From previous data published by reputable authors, a standard effect size 0.3 was established to provide a base-line above which would indicate the influence of intervention by ICALP.

As established in Section 5.9.1 (p 407), a satisfactory level of academic excellence was maintained by UG2 students of anatomy at the end of
1992 and 1993. These data are presented in Figures 181 and 182 (pp 408 & 409), and Tables 77 and 78 (pp 408 & 409). Figure 181 and Table 77 were used to compare the end of year achievements of UG1 anatomy population in 1991 with the UG2 results from the same subject at the end of 1992. In the same way, Figure 182 and Table 78 were applied to compare the end of year results of the UG1 population of 1992 with UG2 results at the end of 1993.

Table 77 and Figure 181 were used to illustrate a uniform progression in anatomical studies from the end of UG1 in 1991 to the end of UG2 in 1992. The mean achievements at the end of UG1 were 70.19% compared with 70.78% at the end of UG2. This information was used to confirm that no adverse effects could be attributed to the intervention of ICALP materials and research methods in the 1991-1992 period.

The same method was used to compare the contents of Table 78 with the presentation in Figure 182. Despite a minor disunity of progression at the end of UG1 in 1992 to the end of UG2 in 1993, the mean value at the end of UG1 was 65.13% compared with 69.10% at the end of UG2. These data again were used to confirm that no adverse effect could be attributed to the intervention of ICALP and research methods in the 1992-1993 period.

From the collective 2-D and 3-D data of the 1992-3 populations, it is clear that neither the ICALP nor the Lecture groups were disadvantaged by the procedures used, showing that a marginal advantage was held by the ICALP population over their Lecture counterpart. From the accumulated evidence presented in Chapter 5, it was possible to declare
that ICALP materials can be used effectively to replace traditional methods when teaching anatomy to physiotherapy students.

Furthermore, the foregoing evidence is supported by the objective and subjective responses from the FeedBack Instrument applied in 1992 and 1993. The composite objective attitude towards learning anatomy from lectures is presented in Figure 169 (p 388), to show the majority of students gained a positive effect when learning by lecture. Nevertheless, from the data presented in Figures 170 and 171 (p 389), it is clear that a significant number show a predominant interest in learning anatomy by computer, or its combination with lectures and laboratory situations.

These findings are somewhat contradicted by a declared ability to learn anatomy independently in Figure 172 (p 390), countered by a diminished desire to do so in Figures 173 and 175. Subjectively, the quantitative information given in Figures 169, and 171 to 175 (pp 388-392) is amplified by a wide range of student responses to ‘valued most - valued least’ questions about lectures from the 1992 and 1993 populations in Appendix A and B respectively (pp 503 to 512). Although the general attitude towards lectures demonstrates a positive acceptance of their value, close scrutiny of the things valued least about lectures is informative, suggesting that students perceived a need for change.

Although student feedback indicated a preference for a learning environment which includes a combination of lectures, ICALP and laboratory materials (Figure 171, p 387), the general level of objective satisfaction to learn anatomy by ICALP in Figure 177 (p 393) is satisfactory at a mean of 3.44, with 26 (17.3%) students registering a margin of dissent, with only one frankly opposed to the procedure. Of
considerable interest, is the general level of satisfaction at a mean value of 3.40 with computer tests in Figure 178 (p 394), supported by a sense of trust in the computerized grading system at a mean of 3.70 in Figure 179 (p 394). Notwithstanding the mean value of 3.78 to register a positive level of enjoyment when learning anatomy in Figure 180 (p 395), the ‘valued most and least’ responses given in Appendix C and D are illuminating (pp 503 to 512). Overall, the subjective remarks support opportunities for self-paced learning, whereas negative comments mainly seek better access to improved computer technology.

From these results, it is possible to assert that ICALP and integrated software can be applied successfully to engender empowered learning by tertiary students of anatomy.

6.2 Effectiveness of ICALP and SOCCER to facilitate Problem-based Learning

As advocated by Reeves (1992a), supported by the previous work of Bransford et al., (1990), the mere presence of interactive multimedia does not automatically guarantee learning. Anbar (1991) defined knowledge to be an effective problem-solving ability through mastery of information learned. Reeves (1992b & 1995) is of the opinion that absorbed information must contain a dynamic affect, otherwise its retention may be deactivated to inert knowledge. However, inert knowledge may be resuscitated by the appropriate test methods espoused by Anbar. To prevent the regurgitation of memorised information, ICALP and SOCCER materials were developed to create a framework of anchored concepts in an integrated knowledge base of action to stimulate the learner to provide solutions to well constructed problems.
In the case-based learn-by-doing environment outlined in Sections 3.40 and 3.41 (pp 231 & 232) of this thesis, problem-based strategies were inculcated into the every-day ICALP activities shown in Sections 4.13.8 and 4.14 (p 259). Initially, unsophisticated but challenging problems were elicited, as in Figure 62 and 63 (p 188), which require the identification of a single solution. Later, with the advent of SOCCER in 1993, more elaborate problems were created for individual dispensation, as illustrated in Figures 118 and 119 (pp 230 & 231).

In 1992, a problem-based approach was developed to involve students with their own rate of progress in a simulated environment of discovery learning designed to show that there is no single explanation to presenting phenomena from individual patients. From this strategy, a philosophy was generated to accept that there is no black and white, all-embracing recipe for the treatment of any single condition. This strategy was devised to move the learner away from a linear way of thinking.

By virtue of ICALP and SOCCER, lectures normally delivered in Semester II of second year were converted into a problem-based learning format. Thus, in Semester II 1992 and 1993, some twenty-eight problems were developed and released in groups of four. Groups of randomised problems were individually delivered to the learner by selection from the problem question assignment box. As discussed in Section 4.14 (p 259), problems were clinically invigorated by the use of Resource Persons, primarily to enrich problem-based learning by first-hand clinical experience in laboratory sessions, with a secondary role to observe the process and submit independent results for assessment by the Subject Controller.
In this way, SOCCER, ICALP, TFTI, and MCQTI strategies were used in collaboration with clinically experienced Resource Persons to retrieve inert knowledge by integration into a self-paced, self-directed, problem-based style of learning. This evidence is given to verify the evolution of traditional anatomy lectures into seminar-discussion sessions, enriched by computer-based learning to enable the introduction of problem-based learning to extend the syllabus to a more advanced level than could otherwise be expected.

6.3 Effectiveness of ICALP to present 2-D and 3-D anatomical information

To resolve the secondary research questions about the facility of ICALP materials to initiate the transfer of 2-D cognitive anatomical information into an effective 3-D skill, it was considered expedient to separate the acquisition of 2-D and 3-D information by the 1992 and 1993 populations.

From the collective 2-D data of the 1992-3 populations, it was clear that neither the ICALP nor the Lecture groups were placed at any disadvantage by the research procedures used in this project. From the data provided by ANOVA, ANCOVA and boxplot, it is also evident that the ICALP and Lecture group populations were at par during their efforts. Although the overall mean values from Tables 55.1 and 55.2 (pp 330 & 331) demonstrate a fractional lead of 0.44 points in favour of the ICALP group.

When viewed separately in Table 55.1, the pre and posttest range of 2-D results of the ICALP and Lecture groups in 1992 were, from 31.96% to 73.35%, and from 32.50% to 73.12% respectively. Whereas in 1993, Table 55.2 revealed a pre and posttest differential between the ICALP
and Lecture groups to be, from 31.15% to 74.47%, and from 37.94% to 73.82% respectively.

When viewed collectively, the mean values of 2-D results from Tables 55.1 and 55.2 reveal a close conformity of achievements by the two experimental populations. At pre and posttest the range of results identified an effect size range from -0.144 to 0.017, and correlation ratios from 0.020 to 0.030. Moreover, the mean achievements of the two components of the 1992 and 1993 research populations at pre and posttest, were from 31.55% to 73.91% by the ICALP groups and from 35.22% to 73.47% by the Lecture groups.

These results are used to verify that ICALP materials can be applied successfully to transfer 2-D anatomical information to undergraduate students of anatomy.

The same approach was applied in the construction of Table 72 (p 362) to observe the 3-D achievements of the 1992 and 1993 research populations. When viewed separately, the pre and posttest range of 3-D results of the ICALP and Lecture groups in 1992 were identified to be from 54.57% to 75.39%, and from 51.33% to 73.22%, respectively. Whereas in 1993, a pre and posttest differential between the ICALP and Lecture groups was found to be from 36.15% to 76.22%, and from 35.51% to 74.66%, respectively.

When viewed collectively, the mean values of 3-D results in Table 72 show a conformity of achievements by the 1992 and 1993 populations; namely, a pre-posttest mean effect size reduction from 0.256 to 0.192, and a pre-posttest mean correlation ratio reduction from 0.045 to 0.018.
Moreover, the mean pre-posttest achievements of the two components were from 45.36% to 75.80% by the ICALP groups, and from 43.42% to 73.95% by the Lecture groups.

Although these results show trends to confirm that ICALP materials can be used successfully to acquire 3-D anatomical information by undergraduate students of anatomy, there is considerable equivocation about its statistical significance whilst doing so.

The decreased effect size of 0.256 at pretest compared to 0.192 at posttest, with a mean correlation ratio of 0.045 reduced to 0.018, indicate no statistical evidence in support of ICALP methods for the transfer of 2-D cognitive anatomical information into a 3-D psychomotor skill. However, from data retrieved by ANOVA, ANCOVA and box plot, there is sufficient evidence to show that the ICALP and Lecture populations were able to sustain an even level of parity in 3-D results, with an ICALP advantage 1.85 points ahead of their Lecture colleagues.

From the feedback in Appendix C and D, there is a clear demand for 3-D imagery in ICALP materials. Accepting that the ICALP modules applied in this project were developed in 1990-91, the attempt to create an illusion of 3-D effect by the mere availability of an alternative screen in a plane at right angles to the one in use could not be sustained. However, with the introduction of more sophisticated computer technology, it would now be possible to create a sustained illusion of virtual reality by clicking on trigger points placed around and within a screen to explore the depths of a structure from a wide variety of perspectives.
To detect any main effect from 3-D studies, it was already evident in 1992 that the ICALP treatment group should be denied access to laboratory experiences during a definitive time slot. Unfortunately, at the UG2 level of that period, it was considered unethical to interfere with the essential components of professional education. In the presence of such constraint, the risks associated with sequestration of 3-D study groups were considered to be unacceptable. However, in view of the data collected, it is clear that neither of the UG2 ICALP populations were disadvantaged by 3-D computer studies, and that definitive 3-D experiments were justified at the end of UG1. In that event, UG1 ICALP and Lecture groups were randomly selected in the final weeks of the academic year for impromptu studies of the cardio-thoracic and central nervous systems. As already established, to avoid a Hawthorne Effect, the roles were exchanged for each topic. In each case, the ICALP groups were simultaneously denied access to lectures and laboratory experiences to reach a positive conclusive about the impact of 3-D ICALP intervention.

6.4 Effectiveness of ICALP to academic staff, individual students, and administrators

Data from this project were applied to compare the relative value of ICALP materials with traditional lecture methods and cost-benefits to academic staff-members, individual students, and administrators. The main advantage of computer-assisted learning is to create a sense of active involvement in the learner by provision of instant reinforcement and feedback. This process was developed via SOCCER to facilitate a feeling of positive self-regard in the learner by self-regulated delivery of personal achievements, thus providing opportunities for low achievers to compete with high achievers (Goldschmid & Goldschmid, 1974).
Although precise information about costs proved to be elusive, sufficient data were gathered to construct Tables 55-1, 55-2, 72, 73-1 to 73-6, 74, and 75-1 to 75-5 to determine the effectiveness of ICALP materials to dispense anatomical information in a CMLE.

During the preparation of this research project, note was taken of the recommendations of Muller (1984) and Walsh & Bohn (1990), who advocate the use of computer-assisted learning to replace existing lectures in anatomy to release its lecturers for other purposes. The effectiveness of ICALP and SOCCER to lecturing staff is verified by the results outlined in Tables 73-1 to 73-6 from ten discrete areas of study. The FeedBack Instrument was used to confirm a positive influence of computerized learning by the majority of students, as shown by perceived rates of achievement from Figures 165, 177 and 180 (pp 386, 393, & 395).

These procedures provide unlimited access to academic staff to survey the efforts of individual, or groups of learners from their own desktop. By virtue of this facility, academic staff can readily obtain information about the quality and quantity of learning taking place, as well as judge the impact of any educational strategy in use. In this way, data can be collated about methods of learning, revision, hours of effort, and workstation activities (Table 74, p 381).

A significant element of ICALP and SOCCER effectiveness to academic staff members, is found in Tables 74 and 76. In a traditional lecture scenario of anatomy teaching over a period of seven semesters, it was estimated that some 15,676 student examination hours would require at least 2,100 hours of marking and grading by academic staff, at a median
range of 16 minutes per two-hour paper. The traditional lecture scenario contrasts markedly with the ICALP and SOCCER experience, with 7,505 hours of specific tests and 1,342 hours of mid and end of semester examinations in the same period. The outstanding benefit of a CMLE technique, is the removal of need to mark and grade examination papers by academic staff. Furthermore, computerized results are immediately available after the exit of the last candidate. Examinations and marking are of significant importance in the field of educational research, as well as to invoke a stimulus for achievement by the individual (Pilliner, 1968). In this project, the onerous task of marking was reduced to a minimum, at the same time providing self-regulated opportunities to individual learners to validate the effectiveness of teaching and other procedures. In this way, ICALP tests were given as pretests to stimulate pursuit of greater success and reward at posttest. The purpose of this process was twofold, firstly to establish empowered confidence by the learner in ICALP and SOCCER, and secondly to guarantee professional competence in parallel subject areas (Entwistle & Nisbet, 1972; Lee, 1994; Oppenheim, Jahoda, & James, 1967).

Dependent upon the creative preference of any academic staff member, the time saved from the task of preparing, processing, and marking examination papers may be used to up-date, or advance the software in use. Alternatively, the time saved by ICALP and SOCCER may be used to, either develop additional ways to empower autonomous learning, or to implement the problem-based approach outlined in Section 4.14 (p 259).

Dependent upon the educational focus of an academic staff member, the value of ICALP, objective tests, and SOCCER, may be used to generate
a core of autonomous self-paced learning. These devices are designed to empower students to work through the syllabus at their own pace, declaring a readiness to take formal tests at preferred stages. In this way, a significant number of students are able to work through essential material to meet standard requirements, whilst others may require occasional rehabilitative attention to sustain their progress. In this way, the tedium of lecturing basic facts to UG anatomy students can be minimised, releasing valuable academic resources for the development of more enlightened presentation.

The success of ICALP materials used by individual students can be determined by evidence from the FeedBack Instrument described in Sections 3.39 and 4.15 (pp 224 & 261), supported by data in Figures 178 to 180 (pp 394 -395), Table 74 (p 381), and Appendices C and D (pp 509 to 512).

Evidence obtained by feed-back to the question in Figure 170 (p 389), illustrates a general level of acceptance to learn anatomy in a computerized environment, with only 7.9% students recording a mild dissatisfaction with the process. These findings are amplified by the responses to the question in Figure 171 (p 389), with 96.7% of students showing a preference to learn anatomy by a combination of Lectures, Laboratories and Computers. Learner reactions are equally positive to the questions in Figures 177, 178 and 179 (pp 393 & 394), with mean distributions at 3.44, 3.40 and 3.70 respectively.

Further evidence of enthusiastic student support in favour of ICALP activity is presented by revision data in Tables 73-1 to 73-6 and 74, verified by 2-D results in Tables 55-1 and 55-2, 3-D results in Table 72,
and supported by the distribution of undergraduate and postgraduate effort in seven semesters from 1991 to 1994 shown in Table 76.

The main advantage of ICALP and SOCCER to undergraduate and postgraduate students of anatomy, is its solid anchor at pretest, followed by a sustained availability to explore, confirm, and revise unlimited information in the certain knowledge that all test items will be generated from the same source materials. In this way, a strong bond is rapidly established between learners, ICALP, and assessment procedures to authenticate academic staff in a secure atmosphere of problem-based learning.

The significant educational benefits of ICALP and SOCCER to individual students of anatomy, entail unlimited access to a range of repeatable and quality assured information, combined with interactive positive reinforcement on each screen, with a summary on the final screen to signal success at the end of each learning episode. In any formal test procedure, these interactive mechanisms of positive reinforcement also apply, interspersed with the diagnostic advice discussed in Sections 3.31, 3.32, and 3.36 (pp 168, 169, & 208).

Throughout this project, the implementation of an examination style of instant reinforcement and rapid feedback is considered to be essential. Student benefit gained by the speed of access to recorded results is immense (Bindman & Elleway, 1985; Gleadow, et al., 1993; Reeves, 1995; Woolfolk & McCune-Nicolich, 1984). This principle was taken into account during the development of ICALP and SOCCER instruments to import the power of instant reinforcement to remove the
customary delay between the time of examination and the realisation of its results (Lee, 1994; Lee & Kemp, 1994).

The effective use of computer-assisted learning in schools of medicine advocated by Holley and Heller (1984), Harkin, et al., (1986), and Wigton, et al., (1990) to enhance the diagnostic skills of physicians formed the ethos of this project. Because the education of modern healthcare professionals involves the acquisition of unlimited information from an ever widening range of contrasting sources (Lee, 1994; Shortliffe & Perreault, 1990), it is evident that such information can only be acquired by self-directed individuals at a conceptual level. These principles were considered to be of the essence during the construction of ICALP and SOCCER components by the creation of intuitive links between disparate items of information (Hutchings, Thorogood, & Hall, 1992; Kidd, Hutchings, Hall, & Cesnik, 1992).

The concept of intuitive learning was accepted as an essential part of the ICALP process in SOCCER throughout this project as an ingredient to induce autonomous life-long learning by anatomy and pathology students to cope with an exponential growth of information beyond the logistics of contemporary resources. In such an environment, each individual must be educated to accept personal responsibility for learning with a willingness to navigate through a rapidly expanding field of professional knowledge. To meet this requirement, it is essential that a personal sense of responsibility is developed within individual students with sufficient self-esteem to acquire a core of essential facts with guidance towards the acceptance of a discipline of life-long self-discovery. The main function of ICALP and SOCCER, is to initiate the
principles of sustained personal growth with an in-built problem-based attitude towards renewable discovery learning.

Undoubtedly the advantages of ICALP and SOCCER in a continually up-dated CMLE are self-evident to any tertiary administrator involved with the provision of enriched resources to engender an environment of self-directed learning. The diverse requirements of academic staff and students to transfer and assimilate a large body of anatomical and pathological knowledge to satisfy the high standards of a professional qualification is paramount. The hardware and software developed by this project in part are recommended to meet these requirements to keep pace with modern educational technology.

Notwithstanding its learning facility, SOCCER provides an abundant database of educational research materials of value to academic administrators. As already mentioned in Sections 5.1.3, 5.1.4 (p 277-282), 5.2 (p 328), 5.4.1 (p 337), and 5.5 (p 359), it is evident that the alignment of parallel subjects within the physiotherapy syllabus generates a firm background of integration to stimulate a high quality product. Evidence to this effect is visible in Tables 73-1 to 73-6 (pp 366-377) which illustrate the quality of computerized learning activities to the 1992 and 1993 populations. By virtue of SOCCER, such data, together with that from companion subjects in the syllabus, can be visualised to make decisions about the most beneficial placement of topics and themes.

From an administrative standpoint, evaluation of the academic performance of individual students in specific subject areas is of prime importance, either at pre-selection, or at other critical stages of
assessment and progression. As a pre-selection device, the stratagems of SOCCER may be applied to obtain, register, and record responses to specific questions for immediate correlation to determine whether a candidate has met the criteria of entrance requirements. Such pre-selective procedures may be used under accredited supervision for candidates from elsewhere. Furthermore, should a candidate be considered for transfer from one academic institution to another, MCTI and TFTIs may be applied to evaluate the level of competence of the entrant to the incoming syllabus. In addition, should such a candidate be preferred, ICALP and other test items available via SOCCER, can be used to inaugurate self-paced learning to either rectify any inter-institutional deficiencies, or to accelerate the advancement of the entrant to meet local standards.

At an internal administrative level, SOCCER and subsidiary instruments, may be used to ensure the availability of sufficient information to assess the comparative success of one cohort with another, as shown by Tables 73-1 to 73-6 (pp 366-377) and 75-1 to 75-5 (pp 397-401), or to make diagnostic predictions of individual ability to establish patterns of learning behaviour, as outlined in the summary of achieved results available to the learner and subject controller in Figure 105 (p 219).

Of equal importance to an academic administrator, is the facility of SOCCER to quickly determine the quality assurance of any method in use, as well as to use FeedBack strategies to determine the effectiveness of an academic staff member who is responsible for such presentation. The quality assurance of methods in use is readily available via SOCCER, with options to apply appropriate questions in the FeedBack style described in Sections 3.39 and 4.15 (pp 224 & 261). Such
quantitative information may be retrieved for presentation, as shown by responses to the questions in Figures 163 to 180 (pp 385-395) for correlation with qualitative remarks shown in Appendices A to D (pp 503 to 512).

Although precise cost-benefits remained obscure to this project, the principles applied to construct Tables 55-1, 55-2 (pp 330 & 331), 72 (p 346), 73-1 to 73-6 (pp 366-377), 74 (p 381), 75-1 to 75-5 (pp 397-401), and 76 (p 405) can readily be adapted to meet such requirements. The academic and educational effectiveness of this method may also be obtained by extrapolation of the data presented by the same group of tables.

Review of data, such as that given in Tables 74 and 76, would enable precise decisions to be made about the cost-benefits of a traditional scenario with a model of computer origin. In Table 76, the advantages and disadvantages of each method are transparent for collation with information from other subject areas. Irrespective of the need for formal end of semester examination papers, Table 76 demonstrates a comparison of lectures versus ICALP over a prolonged period.

A traditional lecture scenario entails many hours of examination preparation with significant student examination hours accompanied by printed examination questions and booklets. Of greater significance, is the sustained wastage of academic staff-time to marking and grading of such examination papers, which could be used to more profitable strategies of empowered learning. Accepting the need for middle and end of semester written-practical examinations in anatomy, ICALP and
SOCCER may be used effectively to reduce sundry expenditure and valuable staff-time by at least 50%.

The major detraction of a computer-managed learning environment is a constant need to up-grade the network of hardware and workstations, by the appropriation of funds to replace obsolete units. If accepted, the cost-benefits of the ICALP and SOCCER educational philosophy, may be applied to support the cost-effectiveness of such an enterprise.

Noting that the administrative provision of the 25 workstation CMLE during the seven semesters of this project in Table 76, the potential availability was 153,125 hours. During that time, 803 UG and PG students devoted 34,492 hours of time to the study of anatomy. To demonstrate the accepted principle of self-directed learning by UG and PG physiotherapy students, 9,808 hours of learning and revisionary effort beyond that formally set aside for anatomy may be visualised from Table 74. Furthermore, the overall proportion of workstation occupation by UG and PG physiotherapy anatomy students was 22.52% of the total time available in the CMLE.

In the traditional scenario shown in Table 76, the expected student hours of self study outside of formal lecture and laboratory hours was estimated to be 782,992 hours for the 803 UG and PG physiotherapy students between 1991 and 1994. The anticipated time-frame of self-study is dispersed between the library and home-based studies. In the CMLE component of this project, it may be perceived that 34,492 of expected hours is set aside for CAL, and that its mere provision results in a boost to its cost-effectiveness. Evidence in support of this notion is demonstrated by correlation of learner attitudes with subsequent results
in Figure 114 (p 227). In response to this question, the 1992 population estimated an average of 4.52 hours of self-study per week, compared with 5.34 hours per week by their successors in 1993. If these results are averaged at 4.93 hours per week for the 803 participants of this project during the 98 weeks of operation, then the declared effort of self-study reached a total 387,961 declared hours in comparison with an expected total of 782,992 hours (Table 76). These data show the declared rate to be 49.54% of the expected rate, representing a personal cost-saving of 395,031 hours of UG and PG student effort in anatomy (Table 75.5).

At a more pragmatic level, with the advent of SOCCER and the presence of Image-Writer printers in the CMLE, it was possible to dispense problem-based learning questions at the expense of the Student Guild, or individual students, saving the administration sundry costs and reams of photocopied paper.

These principles of operation may be used by tertiary education administrators to determine the size of a CMLE and dispersion of workstations to establish a rationale of usage by specific academic disciplines. The core information required to make such academic decisions is exemplified by the database provided in Tables 55-1, 55-2, 72, 73-1 to 73-6, 74, 75-1 to 75-5, and 76.

In previous studies, Lee and Allison (1992 & 1993) and Lee (1994) defined a need to investigate the proportional relationship of ICALP materials with other educational techniques, reinforcing the views of Jones, et al., 1978; Richards, et al., 1987; and Walsh and Bohn, 1990. To sustain the advancement of computerized educational technology by significant healthcare professionals, there is a need for vigilant provision
of imaginative anatomical educational software by supportive tertiary educational administrators. Whether the end product be parochial or commercial, an effective outcome is dependent upon the drive and creative ability of the developer in a mutually supportive administrative environment.

According to Shepard and Jensen (1990), many physiotherapy students at the beginning of their career may not be prepared for professional needs beyond the 1990's. These authors present a curriculum framework to develop a 'reflective practitioner' who may be empowered to autonomously embrace advances in medical technology, in an environment of increasing need to control health care costs, with an aging population suffering from chronic rather than acute illnesses with complex sociocultural problems.

To contend with these changes, Shepard and Jensen recommend Eisner's (1985) model of explicit, implicit, and null curricula. Eisner's null curriculum refers to what is missing, or left out of course curricula. To meet these demands, Shepard and Jensen suggest that academic staff prepare students for future population needs in a cost-effective way, whilst developing collaborative skills to effectively delegate and supervise other colleagues at the technical-level. Other questions raised by Shepard and Jensen relate to assisting the carers of patients to acquire 'hands on skills', at the same time promoting a pattern of autonomous lifelong learning to become a reflective practitioner in tomorrow's world.

From this discussion it was possible to affirm the relative cost-effectiveness of ICALP materials and SOCCER to academic staff-members, individual students, and administrators, for the presentation of
anatomy in an environment which supports the development of autonomous life-long learning.

6.5 The impact of high achievement in EEHB-MCP at pre-selection

As described in Chapters 1 and 3, it is intuitively believed by some anatomists that high achieving students in English, English Literature and Human Biology (EEHB), are more likely to be able to transpose 2-D anatomical information into a 3-D skill than those achieving similarly high scores in Mathematics, Chemistry and Physics (MCP).

Observation of incoming tertiary students indicate that some experience difficulty with the transmission of visual, verbal and written constructs into a third dimension (Arons, 1984; Meals & Kabo, 1980; Rochford, 1985). By convention, schools of anatomy perceive that entrants with well established written and verbal skills are likely to overcome difficulties with the transposition of 2-D information into 3-D images more readily than those with a background of high achievement in mathematics, chemistry and physics (Lee, 1994).

Although this concept had been addressed previously by Lee (1994), Lee & Allison (1992 & 1993), it was deemed necessary to verify the existence of any predisposing abilities at pre-entry by physiotherapy students. To meet this requirement, the FeedBack Instrument described in Sections 3.39, 4.8, 5.1.4, and Figure 113, was applied to measure prior achievements in EEHB and MCP for collation with final scores in anatomy at the end of UG2 in 1992 and 1993.

Although pre-entry scores in the EEHB and MCP could only be verified from 73 students in 1992 and 66 in 1993, sufficient data was retrieved
for this purpose in Figures 155 to 162 (pp 344-358), and Tables 79 to 89-90 (pp 412-424). When the mean scores achieved in both categories were at par for certain individuals, those scores were evenly distributed between the two populations.

Thirty-nine EEHB pre-entrants of the 1991 population demonstrated a mean score of 82.18 compared with a mean of 80.32 achieved by 31 students of MCP origin. At the end of their respective UG2 studies in 1992, the sub-group members achieved mean scores of 70.32 and 70.68, respectively. These data are given in Tables 79 and 79-80.

For the UG1 cohort of 1992, thirty-five EEHB members demonstrated a mean of 79.87 on entry, compared with a mean of 82.77 from 31 students of MCP origin. At the end of their respective UG2 studies in 1993, the same groups achieved mean scores of 69.18 and 69.64, respectively. These data are given in Tables 81 and 81-82 (pp 414 & 415).

From these data, despite mild qualitative differences, there are no other significant difference to the outcome of either population. The matter was explored further to determine any differences of achievement by the two research categories by GEFT scores and 3-D achievements in CNS and CTRS studies.

Scrutiny of the 3-D data in Figures 155 and 156 (pp 344 & 345), indicate a minor reversal of quantitative differences between the GEFT scores of both populations. The EEHB category in 1992 were marginally ahead of the MCP sub-group, whereas in 1993 the situation was reversed in
favour of the MCP category ahead of its EEHB counterpart. When taken together, the 1992 and 1993 results cancel each other out.

When taken collectively, the 1992-1993 CTRS 3-D results suggest that neither sub-group possessed a preference over the other. When taken together, the 1992 and 1993 results appear to cancel each other out, confirmed by box plot data in Figures 183 and 184 (pp 417 & 420). From the observations given in Section 5.4.1 (p 337) regarding CTRS 3-D EEHB-MCP studies, the only conclusion that can be drawn is that the MCP sub-groups of both populations appeared to possess a marginal qualitative difference over their EEHB contemporaries.

During investigations of the EEHB-MCP CNS 3-D results of 1992 and 1993, at pretest, although there was parity between the two subgroups, the MCP category was marginally ahead in Figures 154 and 156 (pp 343 & 345). At posttest in 1992, the EEHB subgroup obtained a favourable gap of 1.27 points ahead of their MCP contemporaries in Tables 87, 88, and 87-88 (pp 421-422). At CNS pretest in 1993, the EEHB category superseded the MCP group in a situation reversed at posttest by a gap of 0.94 points in favour of the MCP sub-group (Tables 89, 90, 89-90; pp 423-424). These data were affirmed by box plot in Figures 185 and 186 (pp 423 & 425). From this evidence, all that may be detected from the EEHB and MCP categories of 1992 and 1993, is an inherent capacity by both to keep pace with the achievements of their contemporaries.

From this analysis it was possible to assert that no discernible qualitative or quantitative differences appear to exist by which to predict a pre-entrant ability among high achieving students of English, English
Literature, Human Biology, Mathematics, Chemistry, or Physics, to transpose 2-D anatomical information into a 3-D skill.

6.6 Effectiveness of autonomous FeedBack

As described in Section 5.8.3 (p 383), the FeedBack Instrument may be applied to evaluate individual abilities and concerns, from which to generate trends of data for research purposes. These results support the findings of other studies which indicate positive student reactions to computer-assisted learning (Fraser, 1986; Fraser & Tregust, 1986; Martin & Szabo, 1990; Jadav, Rani & Kishore, 1990; and Teh, 1993).

The feedback instrument was used to categorise such data under the headings of high school graduate, mature age, or overseas student linked to academic subjects and scores of achievement. Responses to such questions enable the correlation of learner attitudes with subsequent results. In this way, information may be acquired to determine the number of hours per week devoted to the study of anatomy, as well as to evaluate subjective responses to specific questions.

Information may also be gathered to quantify attitudes, particular interests, and preferences, for the correlation of learning styles. These techniques were applied to provide short sentence responses to determine an overview of attitude, as shown in Appendices A to D from the 1992 and 1993 populations. Appendices A and B summarise most, and least, responses to the value of lectures, which suggest a positive attitude to lectures with a definite need for more information. This desire is answered in part by most and least responses to ICALP questions in Appendices C and D. When compared, there is a more eloquent response by the 1993 population in Appendix D than from the preceding population. It appears that the expansive quality of this response may be

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due to the advent of SOCCER, integrated with a platform of problem-based learning in 1993.

Feedback may be used to determine fundamental attitudes toward particular styles of learning, such as the preference for visual images in Figure 166 (p 386), the impact of reading in Figure 167 (p 387), or the stimulus to learning by doing in Figure 168 (p 388). Alternatively, feedback may be used to focus particular attitudes upon the presentation of interactive questions. An example of this is shown by Figure 163 (p 385) to investigate the motive to learn anatomy, immediately followed by Figure 164 (p 385) to gain information about the level of comprehension in anatomy. Such linkage may also be perceived by the interactivity of Figures 174 and 175 (p 392), where the candidate is stimulated to answer a question about learning with friends, immediately followed by an option of independent learning. It soon became clear to participants that their preferences were heeded and that they could influence the development of the model being used.

In the same fashion, it was possible to follow the regime of Skinner (1973) to stimulate thought about the need for computer tests by the question in Figure 17 (p 152), then invoke responses to the question in Figure 179 (p 394) to evaluate the general level of acceptance by the question in Figure 180 (pp 395).

In this way, feedback may be used to assess reaction to a particular educational device, at the same time setting out to establish a framework for its use. Computerized tests are a good example of this principle, without well established pretests there would be no mechanism to provide a stimulus for success at posttest.
In the construction of computerized materials for this project, note was taken of the observations of Skinner (1973), and recommendations of Harvey and Brown (1976), who assert that individual behaviour is determined and shaped by environmental systems which contain reward and reinforcement. With these concepts in mind, SOCCER, ICALP, test items, and feedback were developed to present a sense of personal responsibility in the learner for the acquisition of knowledge in a pattern of life-long problem-based modes of action. From this, it is clear that SOCCER may be applied with confidence to empower learners to become fully self-directed in an environment which provides a continuum of data for educational research purposes.

6.7 Limitations of this study

The main limitations of this study are to be found in the constraints of its obsolete software. Although still effective, the hardware and software used in the construction of SOCCER have since been overtaken by more advanced and sophisticated instruments.

Furthermore, although questions related to the acquisition of 2-D anatomical information from ICALP and SOCCER materials are now resolved, the processes involved with the transition of these facts into a 3-D skill require further investigation. Therefore, the 2-D research mechanisms of this thesis may be applied with confidence to address the effectiveness of more advanced software in the presentation of 3-D anatomical information.

Notwithstanding the limitations identified with definitive models of administrative cost-effectiveness, there remains a perceived need for more research into the limitations of computer-based learning across the
breadth of a physiotherapy curriculum. From this, there is a clear need to establish a ceiling of tolerance by individual students for self-directed computer learning, together with a need to determine the limitations of such time and action should other subject controllers wish to become involved with CBL. As a consequence, it would appear expedient for parallel disciplines in a composite syllabus, to undertake a process of combined evaluation, whereby ICALP and other materials along professional themes are assessed to provide an integrated approach to well constructed problem-based professional questions.

6.8 Significance of this study
Computerized learning devices were introduced in this study to displace the need for formal lectures in anatomy and pathology, to be replaced by a system of self-actualised delivery in an environment which empowers students in a problem-based atmosphere. In this way, the lecturer may be released from tedious tasks to explore more beneficial styles of learning, with a recommendation toward complex problem-based questions supported by clinically experienced resource persons.

The research findings discussed in Chapter 5 confirm the effectiveness of this process. These findings demonstrate a sustained output of high quality learning by undergraduate and postgraduate anatomy students between 1991 and 1994.

The ICALP, test, and feedback items administered by SOCCER in this study are based on quality assured anatomy and pathology lectures to meet the core needs of physiotherapy students in a contemporary curriculum. The presentation of ICALP content was based upon a concept of information reinforced by challenging questions, each
question requiring an accurate anatomical response to consolidate the fabric of wide information. Of further significance, is that SOCCER provides an extensive database of educational research from which to investigate the impact of its various stratagems. Consequently, these research results affirm ICALP to be at least as effective as traditional lectures in anatomy, reinforced by the empowerment of autonomous learning in an administrative cost-effective environment.
6.9 Suggestions for future research

The numerous findings of this project establish a need for a well conceived approach to computer-managed learning to reduce the demands of routine lectures for the presentation of fundamental anatomical information.

These findings support a view that basic anatomical facts can be acquired from computers to promote a sense of empowered, self-regulated learning by participants. This process, together with a careful application of test and feedback instruments, can also be applied to generate a concept of responsibility for the acquisition of future information as a process of life-long autonomous learning.

From this aspect, the following suggestions are made to augment the process of interactive computerized learning:

1: The results of this thesis support a continual need for vigilance in a firm policy of replacement and renewal to up-grade software and hardware in an environment of self-paced learning. Such improvement would incorporate self-contained audio presentations at colour image workstations, with direct access to live subjects for collation with dissected specimens, photographs, video-clips, laser-disc, and virtual reality 3-D options.

2: For anatomical purposes, it would appear essential to provide a specific network of computer workstations which incorporate laboratory and library facilities to enhance problem-based exploratory studies.
3: To resolve remaining questions related to the acquisition of a 3-D anatomical skill during computerized learning, the 2-D research model of this thesis could be re-applied with improved hardware and software, to randomly selected cardio-thoracic, respiratory, and central nervous system to UG and PG anatomy students.

4: Because the subsidiary aim of this study to investigate its cost-effectiveness was only partially successful, there remains a need to pursue the question. To achieve this goal, a more discrete course of inquiry may be undertaken to verify the principles of this study by application of reality tested duty statements in combination with the value of sundry items linked to an inflationary index to resolve the question. This information could be used to determine answers to subsequent research questions whilst evaluating the longitudinal effects of computer-assisted learning.

5: In this project, the qualitative retention of knowledge immediately after and at 60 and 120 day intervals following central nervous system studies demonstrates a model of approach to investigate other themes of learning. Furthermore, the cardio-thoracic and respiratory studies utilised in this project, reveal significant evidence to suggested the powerful influence of academic staff in parallel professional subjects. A well constructed project along these lines would be of extreme value.

In conclusion, the findings of this research project support the cost-effectiveness of interactive computer-assisted learning devices, with test and feedback items, to reduce the need for traditional lectures in anatomy.
From these conclusions, traditional lectures in anatomy may be replaced with confidence, in a problem-based environment designed to generate a life-long pattern of empowered autonomy in the learner.
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APPENDIX A. The things valued most and least about lectures by the 1992 population.

**Things valued most about lectures**
I know what is said in lectures is important.
To get information about what to study.
Learning anatomy to assist me to have a future in physiotherapy.

To enable me to understand myself better.
Explanations - especially about function.
To increase my knowledge base.
To enable me to understand anatomy and pathology.
Lectures are generally interesting.
Explanations!
We are told exactly what we need to learn.
Getting the information on what to study - important things to study.
I appreciate an auditory input to help me understand better.
Getting direction to help me focus on what I need to know.
To gain direction for further study.
To gain lecturer feedback get interesting knowledge.
The holistic approach when other information is given.
Hearing about as well as seeing information presented.
The understanding gained to make sense out of other topics.
Gaining awareness of material to be learned.
I like to listen to what is being said and to get some direction about the topic.
The extra details & general information which generates interest.
To gain feedback and get more interesting information.
Listening to more applied knowledge or more clinical knowledge.
Being able to get a grasp on ideas, and then learn them for myself at home.
Listening to the lecturer!
Such detail and general information creates interest in the subject.
Lectures increase my interest and understanding.
Lectures tell me what to focus my attention on.

**Things valued least about lectures**
When computer images are used.
The degree of importance placed on certain facts.
Insignificant information given not required to be a good physiotherapist.
Having to remember all the terms.
Revision of already understood material.
If I'm not prepared I gain very little.
The uphill struggle with terminology.
Things are often repeated several times.
The pace.
I wish we had more time.
Not always enough time to write down details that I feel are important.
No complaints.
The speed of the flow, I would prefer to work at my own pace.
Information overload.
Too much all at once.
The speed of information given and the noise of other students.
Some lectures lack direction and aren't in depth enough.
Lack of concrete direction to better learning.
Having to sit still for such a long time.
I would like more workshop sessions.

Flashing up pictures.
I can't always hear what is being said.
The speed and I don't listen properly and write as well.
Being too busy taking notes to listen to what the lecturer is saying.

Jokes and humour which I do not understand.
I need more time to write down information.
Would like class notes to save me writing it down.
Need more time for discussion and questions.
**APPENDIX A (continued)**

**Things valued most about lectures**
- Actual examples that I can relate to.
- The information given in lectures is concise and clear.
- Knowing the details that the lecturer is interested in.
- Humour and explanations in lectures is better than mere facts from computers.
- Getting extra knowledge and relating it to pictures.
- Getting an overview and finding out what I need to study.
- Learning about theory.
- Receiving information in addition to that in books.
- Lectures are interesting.
- The professional, competitive, and yet relaxed atmosphere.
- Anatomy lecture points are put across well.
- The general knowledge about the human body which anatomy provides.
- Sexual connotations!
- Connections made between other areas of study.
- Anatomy lectures are usually very interesting.
- I like to listen to anatomical pronunciations to help me understand better.
- To gain specific directions.
- To get the drift of inside information.
- Getting a general overview of what needs to be studied.
- Lectures are informative and entertaining. I like Harry's method of lecturing.
- Getting a review of what I need to study.
- The lecturer.

The explanations given for each thing.
Learning the way the lecturer describes things and wants them learned.
The amount of knowledge the lecturer has to share.

The explanations I receive.

**Things valued least about lectures**
- If I don't know the basics, it all moves too quickly.
- Writing continuously.
- Two hour lectures are hard work and I lose concentration.
- Sitting still for 2 hours.

The content is not always flowing - not enough direction.
- When attention moves from anatomy to personal comments.
- I feel the need for tutorials.
- It would help if we were given clues for the next laboratory session.
- I lose attention after a while.
- Now and then, generalisations occur which are not specific enough.
- I don't have any gripes.

A period of two hours gets a little tedious sometimes.
- We can't go over it again and again like the computer people can.
- It's not possible to be inspired all of the time.
- It is often very hard to take everything in.
- Having to sit at the back sometimes where I miss important asides.

The chattering by some people at the back of the class.
- We could use the time in so many other ways.
- Sometimes the lectures don't seem structured or follow a clear pattern.
- A lot of information all at once.

When my attention span causes me to drift and I lose concentration.
Occasionally the speed and general amount of information is not focused.
Too much to listen to in too short a space of time.
- Skipping back and forth, skipping over topics quickly.
- Lectures are sometimes difficult to follow and to know what is relevant.
- When the lecturer pulls away OHP sheets too quickly.
APPENDIX A (continued)

**Things valued most about lectures**
Finding out exactly what I need to know.
I am guided by the emphasis, with direction to the content required.
To get a good overview of what we need to know.
Getting to know what must be learned.
Examination hints and some of the overheads.
Learning how the lecturer describes things.
To get extra information and explanations.
The odd pearl of wisdom and colourful examples provided by the lecturer.
To find out what we have to know.
I enjoy being directed to what to study, learning the basics with raised interest.
Lectures provide extra info from which to judge things of importance.
To gain insight into what we have to know.
Anatomy lectures set specific information with guidance provided.
Getting direction and watching other people.
Anatomy lectures give me a clear outline of what I should read about.
They tell me what I have to learn. They are interesting.
The thread of lecture content tells me what to give my attention to.
Gaining and understanding - awareness of material to be covered.
Finding the key points to learn what is important later.
Having things explained so that they’re easier to understand when I read about them.
Learning by example.
Listening to someone who knows the subject.
They stimulate my need to learn more facts.
The explanations given with information not easily obtained elsewhere.
To gain more insight into anatomy.

**Things valued least about lectures**
I just need time and space to absorb it all in my own way.
I don’t value things less. I realise the content is huge and needs direction.
We don’t always start with the basics.
Nothing - it all seems relevant.
When the lecturer gets out of the wrong side of the bed!
The inability to stop the lecturer to ask important questions.
Sometimes I’m not sure what is relevant.
Disjointed overheads.
Lectures are redundant. If I knew what to learn I could find it all myself.
Lectures not at my own rate - sometimes too fast - sometimes tedious.
The length of time needed to concentrate on listening.
Projector overheads.
Nothing really! The lectures have been great.
I could use the time in other ways.
Harry’s jokes probably.
Not enough direction given about what I need to know.
I would like more time to discuss important points and take them apart.
Having to learn about specific detail.
Side tracking to other topics.
Sometimes we cover topics too broadly.
It’s difficult to get a sense of perspective, especially of the CNS.
Sitting in the same seat for two hours.
The level of concentration required to keep up.
Graphic detail about human bodies and illness.
It’s difficult to stay focused.
APPENDIX B. The things valued most and least about lectures by the 1993 population.

Valued most about lectures
Gaining the key points to a subject
Learning anatomy to assist me to have a future in physiotherapy.
Listening to information to help me comprehend things better.
Being given specific objectives
To get info about what to study.
To find the specifics of anatomy and pathology.
To increase my knowledge base.
They are a good knowledge source.
Listening. Lecture notes beforehand would be useful.
The lecturers input.
The overheads and sense of humour of the lecturer.
Obtaining information about important things to study.
Getting guidelines about what I have to know.
To get interest for further study.
To show what we need to know.

Some lectures are fun and I enjoy the interaction.
The continuous review which motivates me to learn.
Value from hearing about information presented.
To understand new concepts and learn facts.
Gaining direction for what has to be learned.
The precise key points given.
The extra information which generates interest.
To get interesting information and motivation to learn.
To get interesting facts.
They guide me to discover what I need to know.
Lectures create interest in the subject.
Being given the main information and guidance how to find the rest.
Receiving general information and its clinical application.
The interest stimulated in pathological conditions.

Valued least about lectures
The volume of information.
The need for preparation to keep up with emerging content.
When they go over things I already know.
Confusing generalisations.
Distraction by other students.
The quickness of it.
The pressure of events. It's like being in a pressure cooker.
Huge content and the amount of notes to be taken.
Having to write so much to keep up.
The speed of input.
Occasionally the lectures are too broad.
Not always enough time to write down details that I feel are important.
Two hours is too long for me. I would prefer short bursts of one hour.
Too much revision when there is so much more to learn.
Getting told to read about this and this. We may as well learn
by computer.
Nothing, the lectures are just great.
Sometimes I need more clear direction.
Most information is on the computer programs.
None, I am satisfied with the way we are going.
Remaining still for a long time.
When key points are not given.
Trying to understand what is needed to be understood.
The dark stuffy atmosphere.
Having to take tests and exams with the associated stress.
The quantity of information given.
When other people ask questions I know the answers to.
Sometimes difficult to sort out what is most important.
The continual importance placed on facts.
Sometimes there is a need for more structure and specific direction.
APPENDIX B (continued)

Things valued most about lectures
Waiting for specific directions.
Getting clear, interesting applied knowledge.
They give guidance for study with explanations about other areas of interest.
To get the basics of what I need to look up afterwards.
Getting an outline of what to learn.
Learning key points.
Give a wide interest in a lot of subject material.
To learn basic concepts in preparation for lab sessions.
Relaxed atmosphere.
Information about dysfunction.
The opportunity to relate anatomy to physiotherapy subjects.
Waiting to see what is going to happen next.
Easy comprehension due to antics of the lecturer.
The lecturers sense of humour. The pathology content.
Well organised with good visual presentation.
Lectures with clinical relevance.
To learn from examples.
To gain important facts for my career as a physio.
Guidelines about what I have to learn.
To get an applied view of otherwise dry facts.
Getting to know what I need to study.
To gain further insight from explanations given.
To hear what the lecturer wants learned.
To get direction by the emphasis on certain topics from the lecturer.
Just for the fun of it.
To discover what I need to know.
To get direction about content.
To be kept up to date with what I need to learn.
Being pushed through the wringer to keep me working.
To get hints about tests and discussion raised by overheads.

Things valued least about lectures
Disappointed when specific direction is not given.
When the aims are vague.
Confusion with some overheads.
Lectures are valid, I have no complaints.
When they are non specific.
Sometimes too general.
They need more structure.
My lack of motivation.
When there is no apparent direction.
Complex content which could be spread more evenly.
Information given not required to be a good physiotherapist.
We can't revise it like the ICALP people can.
We need to be reminded of declared objectives.
I used to think lectures were great but now I want to discuss problems.
I like the way we are given lectures.
When the content has no importance to physiotherapy.
Distraction from what's going on by others students.
I find pathology distasteful.
I would like more detail and less generalities.
A lot of information all at once.
When I lose concentration.
When I have an assignment and could use the time more effectively.
When we are too short of time to take it all in.
When the content is predictable. I prefer the unexpected.
Now I accept responsibility for my own learning. I get restive.
When there isn't enough clarification of a topic.
When there isn't enough time given to my problem assignment.
Too much anatomy.
I could use the time in other ways.
Lack of time for free discussion.
APPENDIX B (continued)

Things valued most about lectures
To get explanations and direction about their application.
The listen to examples discussed by the lecturer.
Learning how to describe things.
To make sure I'm on track with my self-paced studies.

To get the basics.
To ask questions about things I'm confused about.
Lectures provide extra info from which to judge things of importance.
To gain insight into what we have to know.
Getting direction and watching other people.
They give me a solid sense of direction, especially in pathology.
Lectures tell me what I have to learn. They are interesting.
The thread of lecture content tells me what to give my attention to.
Having things explained so that they're easier to understand when I read about them.
To get an up to the minute picture of events.

Things valued least about lectures
I would like more time to discuss important points.
Sometimes topics are left in limbo.
When I need more direction about what to learn.
It's difficult to hold some information, that's when I prefer ICALP learning.
When they are too fast for me to keep up.
I have no concerns, the lectures have been right on target.
Having no excuses for not learning the stuff.
Trying to keep still.
Perhaps lecture notes would free us up for more discussion.
No comment.
Stay cool man, we can't do without lectures entirely.
When they slip off the topic.
Being driven to learn more than I feel I want to.

When we go over facts we could get from a text book.
APPENDIX C. The things valued most and least about ICALP by the 1992 population.

**Valued most about ICALP**
- The diagrams and information to support them.
- Know location of targets for ICALP tests.
- We can practice as much as we like without too much hassle from lecturers.
- I can do it in my own time and motivation.
- Independence of learning and choice of time.
- ICALP learning is visual and I don't have to do much writing.
- I prefer to do it in my own time.
- I can go at my own pace and draw to become familiar with the diagrams.
- I can look back to ensure that I have learned every detail. Also that it is a self-paced system.
- It gives me a different perspective to learning.
- I can move at my own pace.
- Very good.
- Getting into the subject in my own way.

**Valued least about ICALP**
- Its only 2-D and hard to picture in 3-D.
- Could do with more information in some places.
- For basic learning its fine, but it keeps me awake at night.
- Having to strain my eyes.
- Lack of full explanation.
- It soaks up my time, which I feel I should use for other things.
- Having to use my head continuously.
- Takes a lot of time.
- There is no way to question anything.
- 3 attempts blown if I don't know the answer.
- If I have a question or query there is no one to ask about it.
- Nothing against it.
- ICALP material is sometimes frustrating. I need more 3-D and movement.
- Hard work.
- Too impersonal. I miss the tit bits from lectures.
- No authority figure to refer to when I need to asks a question.
- Not enough computers and access to them.
- Lack of expansion to coordinate my knowledge.
- Other people asking me questions while I am working.
- Not much to complain about, I like working on computers.
- The pictures aren't quite like the real thing.
- The stuffy atmosphere.
- Two-dimensional pictures as opposed to real specimens.
- Fighting my way through other students to get to a computer.

Everything is there for me to learn from.
All the work is there. Just what I need to copy it all down.
The self pace learning and the number of times I can use it.
ICALP provides more information than lectures and we can spend the time however we like.
Straight forward and specific about what to learn.
The chance to learn and browse in my own way without interference.
ICALPs help me to relate facts to function.
It get time to look at diagrams for as long as I like and take notes at my own pace.
Its great, I can pace myself and quit when I'm ready.
Spending as much time as I need to, learning at my own speed.
Being able to see entire models of things instead of just pieces of them in the lab.
APPENDIX C (continued)

Valued most about ICALP
Looking at pictures from a different perspective than in a text-book.
To get the results of my efforts at the end of each session.
Good diagrams and information to help me learn and understand.
In ICALPs I can see where things are in relation to each other.
I can go at my own pace and go back to diagrams if I want to.

The written component is sometimes absent.
The visual display and raw facts given.
Good diagrams.
The relationship of theory to pictures.
The opportunity to use my own time to understand the material.
Seeing the anatomical diagrams.
It is a different and interesting approach to learning.
Is good for revision.
I can learn at own pace and can visualise it all at same time.
I can put in a lot of time into it if I need to.
It allows me to learn at my own pace.
Self paced and I can go back as much as I need to.

Freedom to learn at my leisure.
I am able to go at my own pace.
The freedom to go over subjects as often as I like.
I can go over anything when I like. Good pickies!
The visual input.
The visual presentation of data helps me to relate theory to facts.
Being able to see diagrams in a different way which reinforces my
learning.
The chance to use my own time to absorb important detail.
I can learn at my own pace and style, no need for other people or
lectures.
It gives me time to learn in my own way.

Valued least about ICALP
No comment.
Learning by labels is good via ICALP.
Lack of lectures.
Not knowing what to concentrate on.
Sometimes I can't see it in 3-D then it's hard to get pictures into
perspective.
Written component sometimes absent.
Its there for me, I have no excuse for being lazy.
No explanations available if I don't understand.
The points to click on are too specific and precise in exams.
It can be monotonous for four weeks in a row.
Not understanding the theory.
The frustration of finding how much more I have to learn.
No comment, I haven't seen it all yet.
Its sometimes a bit vague to me.
Difficult to gauge how much time I should spend at it.
Insufficient information provided.
Computers crashing and we miss out on the info Harry gives in
lectures.
Occasionally I don't get connections with functions.
Not as good as real specimens or textbooks.
Not being able to use them at the weekend.
Would like more interaction.
Apparent irrelevancies.
Sometimes it seems like more terms with no meanings.
The neuro anatomy needs more detail.

It would be useful to be able to take ICALPs home to work on.
If not fully understood its up to me to find out. Fair enough I suppose.

They would be better in the library for cross-reference.
APPENDIX C (continued)

Valued most about ICALP
Structures are clearly defined and visible. Relationships easy to see & learn.
The key points of each of the topics are clear.
I am able to go at my own pace.
Getting the visual images which can be applied to the real thing.
I enjoy a different style of learning but others getting lectures detract from this.
I can do it at my own speed.
It's independent - what I learn is up to me.
Memory retention seems better.
I like the clear pathway which makes it easy to see and learn.
I can do it my way at my own pace.
I can come in at my own time to learn at my own pace.
Terrific, I can learn at my own speed at my own time of choosing.
Self paced, an I can re-play it all to get immediate feedback.
Being able to memorise the information together with the pictures.
Great, I can do it at my own speed.
Can learn at my own pace.
It a good way to learn and I can find out what I need to know.
I know instantly when I have made a mistake.
Seeing animated pictures.
They help me to get a better perspective of what anatomy is about.
The preciseness of information covered.
It helps to prepare for computer tests and exams.
The information is clear and to the point.
Fitting fragments of information into a pattern.
The ability to learn in my own time and at my own pace.
Its a unique way to learn and what I get out of it is up to me.
Information linked to visual images.
Continuous feedback.

Valued least about ICALP
Sometimes there is less theory or direction. Only sparse amounts are given.
We don't get to hear the lecturer's perspective on each topic.
The inability to get further info besides that given.
The occasional computer stuff up.
The lack of direction & theoretical information.

I would like more information.
There is no way to escape.
It can be rather dull.
More explanation and 3-D diagrams please.
I can't ask the computer any questions when no explanation is given.
Computer screens gives me a headache.
Pity we can't get colour.
Can't ask any questions.
Not having input from the lecturer.
Doesn't look real to me but I am computer clumsy !
I need more specific guidelines.
One day we will be able to free-wheel around and inside diagrams.
Causes me to waste too much time on unnecessary detail.
Sometimes requires more detailed information.
I can't 'reach' the specimens to look at the other side.
The lack of general understanding before learning specifics.
In some packages there are few explanations only identifications.
I miss the back-up information of lectures.
Having to dig for information.
Computers hate my guts.
The way it calls me back. There is always something more to discover.
I need more human interaction and feedback.
I need to get more explanations.
APPENDIX D. The things valued most and least about ICALP by the 1993 population.

Valued most about ICALP
Using SOCCER and seeing diagrams.
We can practice as much as we like without too much hassle from lecturers.
SOCCLER is very good. I have less anxiety when preparing for exams.
The ability to learn at my own pace and I enjoy the diversity.
Know location of targets for ICALP tests.
Getting my results from SOCCER and independent learning.
ICALP learning is visual and I don’t have to do much writing.
SOCCLER is an easy way to learn. I prefer to do it in my own time.

I can go as often as I want and take time thinking about answers.
Instant review with rapid feedback.
The opportunity to relate test books with extra material.
ICALPs provide heaps of information on things I need to know.
Great for revision at my own pace.
SOCCLER puts everything is there for me to learn at my own rate.
ICALPs clarify what I have to know.
Looking at pictures from a different perspective than in a text-book.
The self pace learning and the number of times I can use it.
I enjoy SOCCER and getting additional information from the I-I.
Being able to work at my own pace.
Using SOCCER to get concise information.
The extra information and content of I-I boxes.
I can take notes at my own pace.
SOCCLER and ICALPs are great, I can pace myself and quit when I’m ready.
The visual display and information given.
The continual flow of information via SOCCER.
To get the results of my efforts at the end of each session.
The reliability of SOCCER and that it is self paced.
The information given stimulates me to seek more.

Valued least about ICALP
The tests and not having enough time.
Sometimes 2-D learning is inappropriate, but for basic learning its fine.
Nothing against it.
Difficult content, especially when learning about the cerebellum.
Needs more theory.
The time required to do them.
I have a tendency to rush when I’m on the computer.
Sitting at a computer with the danger of pressure sores on my ischial tuberosities.
I need tests to motivate me to go to the computer lab.
Some answers seem to be too specific and obscure.
Difficult to hit the target.
If I have a question or query there is no one to ask about it.
I sometimes get frustrated by the keyboard.
Time consuming.
The week before exams when I can’t get to a computer.
The feedback is impersonal.
There is not a library to refer to or ability to question at the time.
When answers are not provided for the questions I want to ask.
Note being able to discuss points with the lecturer.
None that I can think of now.
The inaccuracy of some diagrams when exact spots have to be hit.
The length of the process.
Its so compulsive.

People talking in the computer room, it disturbs my concentration.
That the results are assessed.
Learning by labels is good via ICALP.
Nothing, leave it the way it is.
Regrettably it is only in 2-D.
APPENDIX D (continued)

Valued most about ICALP
Another medium to reinforce my learning.
I can do it in my own time giving me more time for other subjects.
Helps me to remember things more clearly.
Good quality information and a stimulus to learn.
That a vast area of information can be covered in a short space of time.
SOCCER provides a great source of related information.
Getting instant feedback and the fun with mousedowns.
Their reliability and repeatability.
Getting positive reinforcement if I get something wrong.
The wide amount of information available from SOCCER.
Self paced, visual with quick responses and answers.
Discovering new ideas about anatomy and pathology.
Self paced and I can go back as much as I need to.
Freedom to learn with additional insight into my processes of learning.
I can take my own sweet time when learning.
Additional information which is directly related to up-coming exams.
I am able to go at my own pace.
I can go over anything when I like.
They are good preparation for exams.
Additional reinforcement to my regular learning habits.
Being able to see diagrams in a different way which reinforces my learning.
The chance to use SOCCER in my own time to absorb important detail.
I can learn at my own pace and style, no need for other people or lectures.
It gives me time to learn in my own way.
Structures are clearly defined and visible. Relationships easy to see & learn.
The key points of each of the topics are clear.
I am able to go at my own pace with explanations about the diagrams.
SOCCER is independent - what I learn is up to me.

Valued least about ICALP
Time consuming and I get tired of reading screens.
Boredom when there is a lot to work through.
Unclear pictures and irrelevant topics.
Repetition of some information in several packages.
That it takes me some time to perceive the diagrams.
When more information is required.
The threat of exams at the end of it.
Unfortunately not as good as real life.
Nothing - I like it.
My biggest problem is getting to a computer at peak times.
The computer lab is very cold.
None, the ICALPs and tests are VG.
When the computer crashes.
Time consuming.
Its just too good, there are no worries whatsoever.
More.
The diagrams are not as accurate as real specimens or textbooks.
Would like more interaction.
They take up a lot of my personal time.
Often too long, I hate staring into a computer screen for 5 hrs !
The neuro anatomy is bewildering at times.
Because of part-time work I would like to use ICALPs on a Sunday.
If not fully understood its up to me to find out. Fair enough I suppose.
Not enough explanation.
Sometimes there is less theory or direction. Only sparse amounts are given.
We don't get to hear the lecturer's perspective on each topic.
The inability to get further info besides that given.
Spending so much time with a computer!
**APPENDIX D (continued)**

**Valued most about ICALP**
Getting the visual images which can be applied to the real thing.
I can do it at my own speed to learn things not mentioned in lectures and labs.
I enjoy a different style of learning but others getting lectures detracts from this.
Memory retention seems better and I get the benefit of an immediate score.
I like the clear pathway from SOCCER which makes it easy to see and learn.
I can do it my way at my own pace and its more flexible than going to lectures.
I can come in at my own time to learn at my own pace.
Terrific, with SOCCER I can learn at my own speed and at my own time of choosing.
Self paced, and I can re-play it all to get immediate feedback.
Being able to memorise the information together with the pictures.
Great, I can do it at my own speed.
SOCCKER is a good way to learn and I can find out what I need to know.
Quick feedback for my efforts.
Seeing animated pictures and I only need to write down main points.
They help me to get a better perspective of what anatomy is about.
The information is clear and to the point.
Fitting fragments of information into a pattern.

**Valued least about ICALP**
Having to work out left from right and striking within 1mm of the target.
Not all the information needed is present.
Memory retention seems better and I get the benefit of an immediate score.
Its sometimes chaotic. Just give us a list of what we have to know.
Sometimes there is a need for more explanation and options to go to other diagrams.
I can't ask the computer any questions when no explanation is given.
Computer screens give me a headache.
Pity we can't get colour.
Can't ask any questions and some programs take up to 6 hrs.
Not having input from the lecturer.
I can't wait for virtual anatomical reality!
Perhaps you can give more options to 'look' around and inside anatomy structures.
When there is no interaction.
Sometimes requires more detailed information.
I want to get inside specimens to get a more real perspective.
I miss the back-up information of lectures.
Having to dig for information.